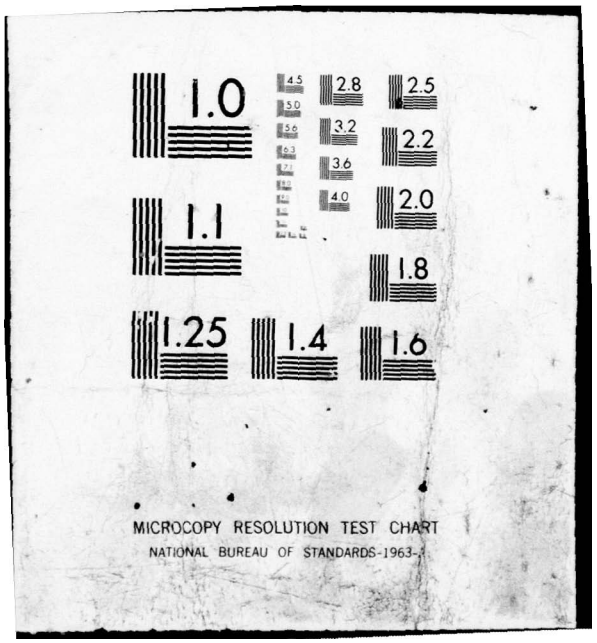
AD-A084 005 GOULD INC GLEN BURNIE MD CHESAPEAKE INSTRUMENT DIV F/G 13/10.1
DEPLOY/RETRIEVE STORAGE SYSTEM (DRSS). VOLUME II. PART II. COMP--ETC(U)
1980 N00039-79-C-0329
NL

UNCLASSIFIED

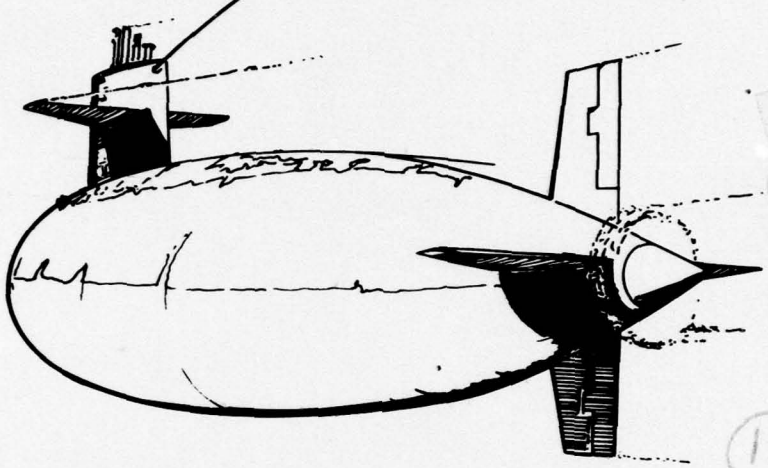
1 OF 3
AD
A084005




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

DEPLOY/RETRIEVE STORAGE SYSTEM (DRSS)

VOLUME II
COMPONENT DEFINITION APPENDICES



ADA084005

LEVEL III

A084004

DTIC ELECTE MAY 9 1980 S D C

This document has been approved for public release and sale; its distribution is unlimited.

SUBMITTED TO:

DEPARTMENT OF THE NAVY,
NAVAL ELECTRONIC SYSTEMS COMMAND
WASHINGTON, D.C. 20360

IN RESPONSE TO:

CONTRACT NO. N00039-79-C-0329

SUBMITTED BY:

GOULD

CHESAPEAKE INSTRUMENT DIVISION
6711 BAYMEADOW DRIVE
GLEN BURNIE, MARYLAND 21061

80 8 21 062

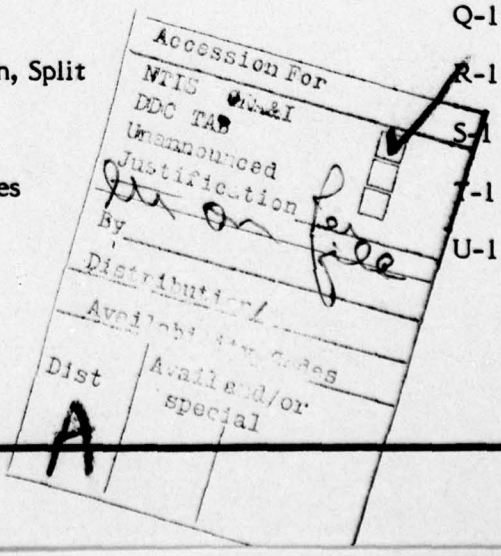
COMPONENT DEFINITION

APPENDICES

APPENDIX

TABLE OF CONTENTS

		Page
	INTRODUCTION	iii
Appendix A	Idealized Linear Traction Device	A-1
Appendix B	Idealized Clamp Traction Device	B-1
Appendix C	Idealized Single Drum Capstan	C-1
Appendix D	Idealized Laminar Fluid Device	D-1
Appendix E	Idealized Direct Windup Assembly	E-1
Appendix F	Structureborne Noise Analysis	F-1
Appendix G	Cable Analysis Tests	G-1
Appendix H	B.C.A. Depth vs. Speed-of-Advance Computer Analysis	H-1
Appendix I	B.C.A. Bending - Storage Assembly/Capstan Characterization	I-1
Appendix J	Storage Assembly - CHETSA Concept	J-1
Appendix K	Storage Assembly - w/Levelwind	K-1
Appendix L	Storage Assembly - Pressure Proof Access Trunk	L-1
Appendix M	Storage Assembly - Barrel Stuffing	M-1
Appendix N	Characterization of Dynamic Seal Leakage	N-1
Appendix O	Characterization of Dynamic Seal Heat Transfer	O-1
Appendix P	Dynamic Seal, Variable, Articulated Segment	P-1
Appendix Q	Dynamic Seal, Variable, Bladder	Q-1
Appendix R	Dynamic Seal, Fixed, Two Position, Split	R-1
Appendix S	Dynamic Seal, Variable, Iris	S-1
Appendix T	Hardware/Manufacturers Brochures	T-1
Appendix U	Data Base Tabulation	U-1



COMPONENT DEFINITION APPENDICES

INTRODUCTION

This volume contains the component definition appendices which are the data base for the Final Report of the DRSS study effort. Specifically, each appendix is intended to present a summary of the characterizations, assumptions and analyses required in order to define configuration concepts. This material establishes the basis for support of the conclusions reached in the Final Report.

The intent of providing this large body of support data is to (1) assure the establishment of a broad data base at the inception of the DRSS study effort, and (2) to provide the maximum amount of material for review and evaluation in order to expose the design assumptions, and permit assessment of the conclusions reached as a result of this study effort.

APPENDIX A

APPENDIX A

IDEALIZED LINEAR TRACTION DEVICE

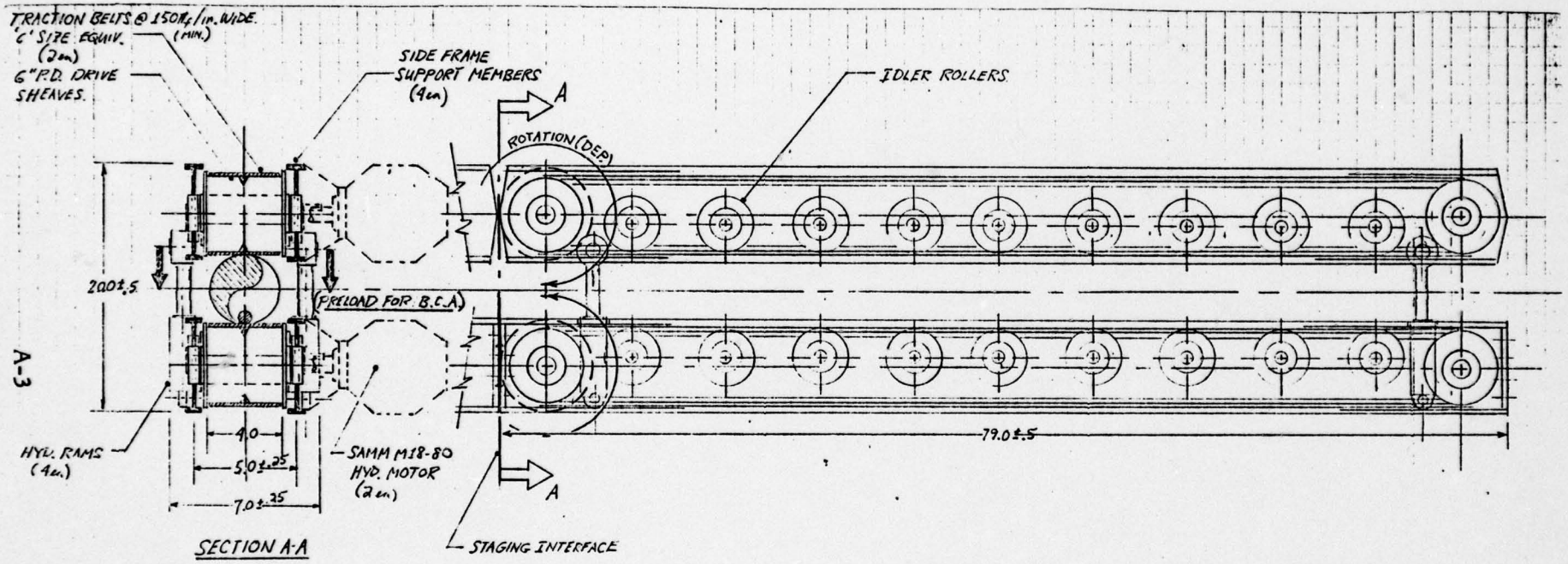
APPENDIX A

IDEALIZED LINEAR TRACTION DEVICE

- Configuration: Multiple Stage, Tandem Belt, Articulated w/Conformal Clamps or Gripping Attachments to the Belts (2-Point Contact).

- Operation:
  (a) Articulated positive pressure loading of one belt against the other -- which is opened to accept an Antenna Element. 4" OD.
  (b) Both Belts are direct driven and drive(s) sized to provide the required 100#/linear ft and minimum operational speed of 200 FPM.

- Considerations:
  (a) Stage synchronization is required -- including inter-stage.
  (b) variance dictates amount of cable contact loading required.
  (c) Dyn. Load Cap. directly proportional to Length. Note qualification by Test Data Appendix G and Load Cap. consideration per Appendix H defining B.C.A. limitations and operational envelope requirements. Appendix I also applies.
  (d) Contribution (Dyn. Load) of the Storage Assy. is not included.
  (e) Configuration adaptable to seawater exposure.
  (f) A single stage failure need not cripple functioning of the entire multiple state configuration, if design allows articulation to non-contact mode.
  (g) Structureborne Noise limitations per Appendix F.



IDEALIZED LINEAR TRACTION DEVICE

REV 'A' 10/18/79
W. R. RICHARDS

1. Finding overall HP required:

   - Refer to Section 3, Part 1. Minimum Input HP required @ 3000#$_f$, μ = .40 w/90° of Conduit/Guide Tube Bend.

     = 27.12 @ 200 FPM

     = 54.24 @ 400 FPM

     = 54.24 @ 6000#$_f$ and 200 FPM

     = 108.48 @ 6000#$_f$ and 400 FPM

2. Finding incremental HP required/Stage - linear foot:

   - Input HP/Linear ft (@ 100#$_f$/ft max loading)

     = .904 HP/ft @ 3000# and 200 FPM

     = 1.808 HP/ft @ 3000# and 400 FPM

     = .904 HP/ft @ 6000# and 200 FPM (Note: due to # stages only)

     = 1.808 HP/ft @ 6000# and 400 FPM (Note: due to # stages only)

3. Characterization of Drive Belt Requirements and Pulley Sizing*:

   - Assuming Belt Drive, w/6' minimum staging length w/2 Powered Belts = 5.424/2 = 2.712 HP/Belt (1 Driver/Belt) -- Find Equiv. Belt Size

     RPM @ 3.0"PD; @ 4.6"PD; @ 6"PD and Belt Size @

(200 FPM)	255	170	128	(2.712HP) =	?
(400 FPM)	510	340	256	(5.424HP) =	?
(200 FPM)	255	170	128	(2.712HP) =	?
(400 FPM)	510	340	256	(5.424HP) =	?

*Ref. Dodge 33-4, 5 Table 1

- Check HP rating/Belt vs Pitch Diameter for Belt Sections 'A' and 'B'*. (Rounded to nearest .05 HP)

FPM	3.0 P.D.		4.6 P.D.		6.0 P.D.	
	A	B	A	B	A	B
200	.30	-	.45	.60	.50	.65
400	.55	-	.70	.85	.90	1.25

- Analysis

(a) No. of Belt Sections reqd to achieve 200 FPM and 2.712 HP

FPM	3.0 P.D.		4.6 P.D.		6.0 P.D.	
	A	B	A	B	A	B
200	9	-	6	5	6	5
400	5	-	4	4	3	3

As 'A' Section is 1/2" w x 5/16" h

and 'B' Section is 21/32" w x 13/32" h

$\therefore$ 4.6 PD → 6.0 P.D. Pulley/Sheave required in order to keep belt width < 4 inches (design constraint)

(b) Comparison of Flatbelt Capabilities vs 'A', or 'C' Section Belts (select a Dandux Grip Star Model GS303N, 3 → 5 ply neoprene or rubber)

@ 4.6 P.D. -- Belt 5/16" thick, = $90\#_f$/linear in. width recommended loading

@ 6.0 P.D. -- Belt 11/32" thick, = $120\#_f$/linear in. width recommended loading

where μ required = .40 for polished steel (μ = .51230 for A, B Section 'V' Belts)

As tensile loading required/belt equals $300\#_f$, Factor-of-Safety = 1.20 for 4.6 P.D. Sheave and = 1.60 for 6.0 P.D. Sheave

---

*Ref. Dodge 33-36, 37

(c) Conclusions:

- Select Flatbelt Configuration, similar to Dandux Grip Star GS303N, 3 → 5 ply
- Select 6.0 P.D. Pulley Size, with possible optimization to a minimum 4.6 P.D. Pulley Size

4. Characterization of Structureborne Noise:

- Refer to Appendix F. At > 200 RPM, the amplitude tolerance become critical. Drive motor(s) will be the major source of generated noise. Structural resonance(s), interstage coupling effects must be evaluated. Engineering judgment indicates that any major problems can be resolved and/or isolated; Prototype testing is essential!

5. Stage Length Characterization:

Select 6' and spacing as a typical characteristic length for the following reasons:

- Minimum 5 stages required to achieve 3000#$_f$ capacity, if use 5' $\mathbb{C}_L$ spacing requires 6 stages and 4' $\mathbb{C}_L$ spacing requires 8 stages. If select 6' $\mathbb{C}_L$ spacing -- impact on stage loss of driving capability vs Antenna Element Length of 4.0 → 6.0 ft becomes greater.
- Minimize number of interstage couplings, overall complexity, maintainability, interface requirements. Note that, per 3(b), where driving capacity F.S. equals 1.60 -- the potential exists to reduce the number of stages to 3, per Cable Analysis Test results presented in Appendix G.

6. Articulation Characterization:

- Assuming contact loading (preload) required at 100#$_f$/linear ft, at a μ of .51230, equals 195.2#$_f$ -- or approximately 1200#$_f$ preload/stage. As the stage must articulate thru a 4.0 → 6.0 in. opening, a 200 → 300#$_f$/in. "spring constant plus preload" is required. Select 4 in. stroke hydraulic rams-pressure compensated - to achieve uniform preload during Antenna Element passage thru a single stage.

7. Envelope Requirements:

- Per Figure 1, each stage requires 6.40 ft^3 (for 4.0 in. Antenna Element capacity).
- For 3000$\#_f$ dynamic load capability, net requirement equals 32.0 ft^3.
- For 6000$\#_f$ dynamic load capability, net requirement equals 64.0 ft^3.
- Note: if can employ technique discussed in 5, above, can reduce envelope to 19.2 and 38.4 ft^3 respectively.

8. Weight Requirements (per Stage) and Cost Estimate:

Components	Hardware Cost Est.	Wt. Est.	Wt. Est. w/ Lightweight Tech.
• 6" P.D. Pulleys - 4 ea. @ 14# in.	$ 240	54	-18
• 4 in. Idlers - 18 in. @ 5.0# in.	360	90	-30
• Flatbelts, 5 ply x 4 in. - 2 ea @ 1.9#/linear in. x 545.1 in. long	200	10	-
• B.C.A. gripping attachments est. @ 50% Flatbelt sizing and $	100	5	-
• Side Frame Support Members w/Pulley and Idler Bosses - 4 ea @ 50.3#	3500	200	-67 133
• Hydraulic Rams - 4 in. @ 6#	200	24	-
• SAMM M18-80 Hyd. Motors @ Required Torque = 75'#; RPM = 128 256; Disp = 4.94 $in.^3$/rev.; 2 ea @ 30.5#	800	61	-
• Misc.	400	6	-
	$4800	450#	115 → 181# possible reduction ($\bar{x} \simeq$ 150#)

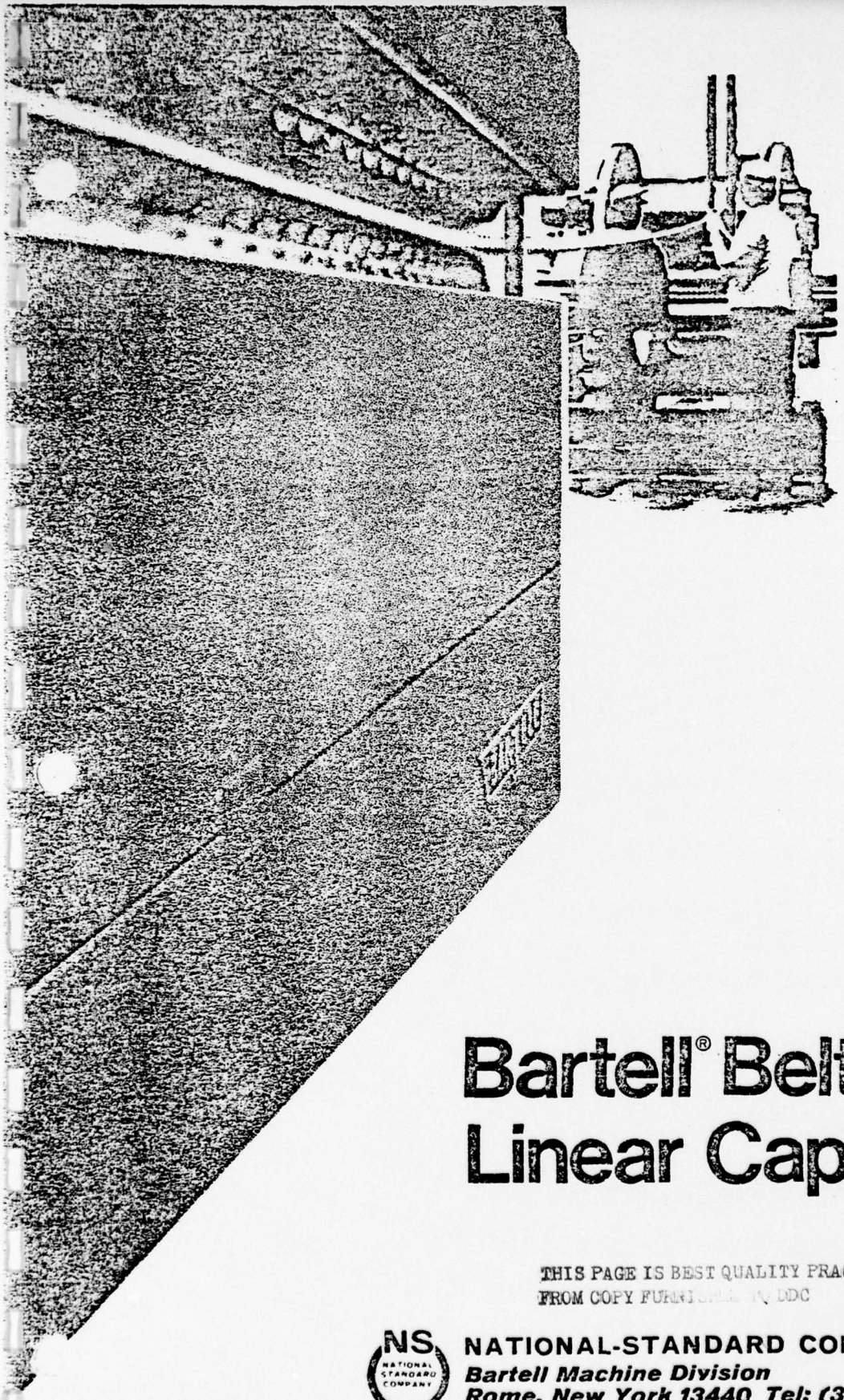
Best Wt Est/Stage w/33% wt Reduction thru Lightweight Technology application -- equals 300#

9. Comparison to Bartell LC-54 Linear Transfer Mech. (see attached brochure).

- Requires 154 ft^3/2000$\#_f$ dynamic load cap. and Est. Wt of 2400$\#_f$. Cost - $18,500 in 1979$
- Factor comparison for equivalency @ 3000$\#_f$ cap:
  - Envelope Reduction of 7.22x for Concept Config.
  - Weight Reduction of 2.40x for Concept Config.
  - Cost Reduction of 1.16x for Concept Config. (excluding assembly and testing)

10. Components Tabulation: (per Stage)

	No. Required	
• Pulleys	4	
• Pulley Brgs	8	
• Idlers	18	(sealed and/or bushings)
• Idler Brgs	36	
• Flatbelts	2	(sealed and/or bushings)
• Hyd. Motors	2	
• Hyd. Rams	4	
• Side Frame Support Structures	4	
	78	



Bartell Belt-type Linear Capstans

Bartell® Belt-type Linear Capstans

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

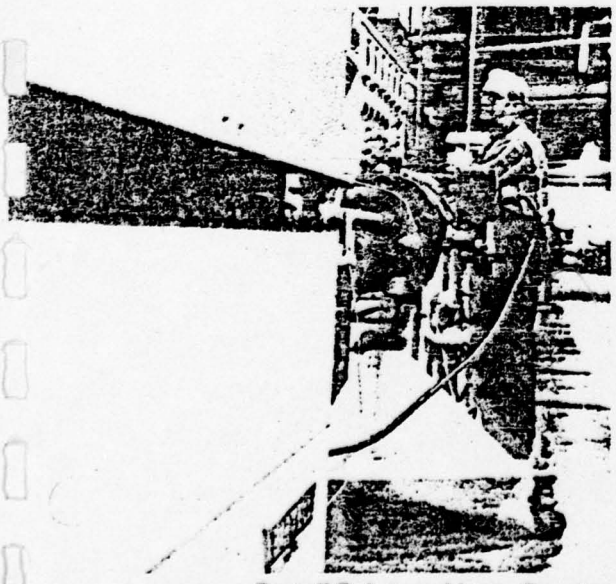
NATIONAL-STANDARD COMPANY
Bartell Machine Division
Rome, New York 13440 Tel: (315) 336-7600

William R. Richards

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Bartell Belt-type Linear Capstans

All three models of Linear Capstans feature dual-track movement



Bartell Belt-type Linear Capstan metering cable to an extruder.

Superior track design centers cable, extends belt life.

On Bartell belt-type linear capstans, both upper and lower tracks move to open and close, automatically centering all diameters of cable on the wire line. The whole track assembly — end pulleys, back-up rollers and belts — moves as a unit, unlike competitive machines where only the roller assembly moves, and an air cylinder is required to take up tension. With Bartell's design, belt tension is not affected when opening and closing, and "scuffing" between belts and cable is minimized.

"Tilting" track more efficient than stationary

On models LC-40.5-T and LC-54, the upper track assembly can pivot about a horizontal axis to efficiently follow changes in cable diameter. The pivot axis is located near the lower surface of the upper belt to eliminate any tendency of the upper track to "climb".

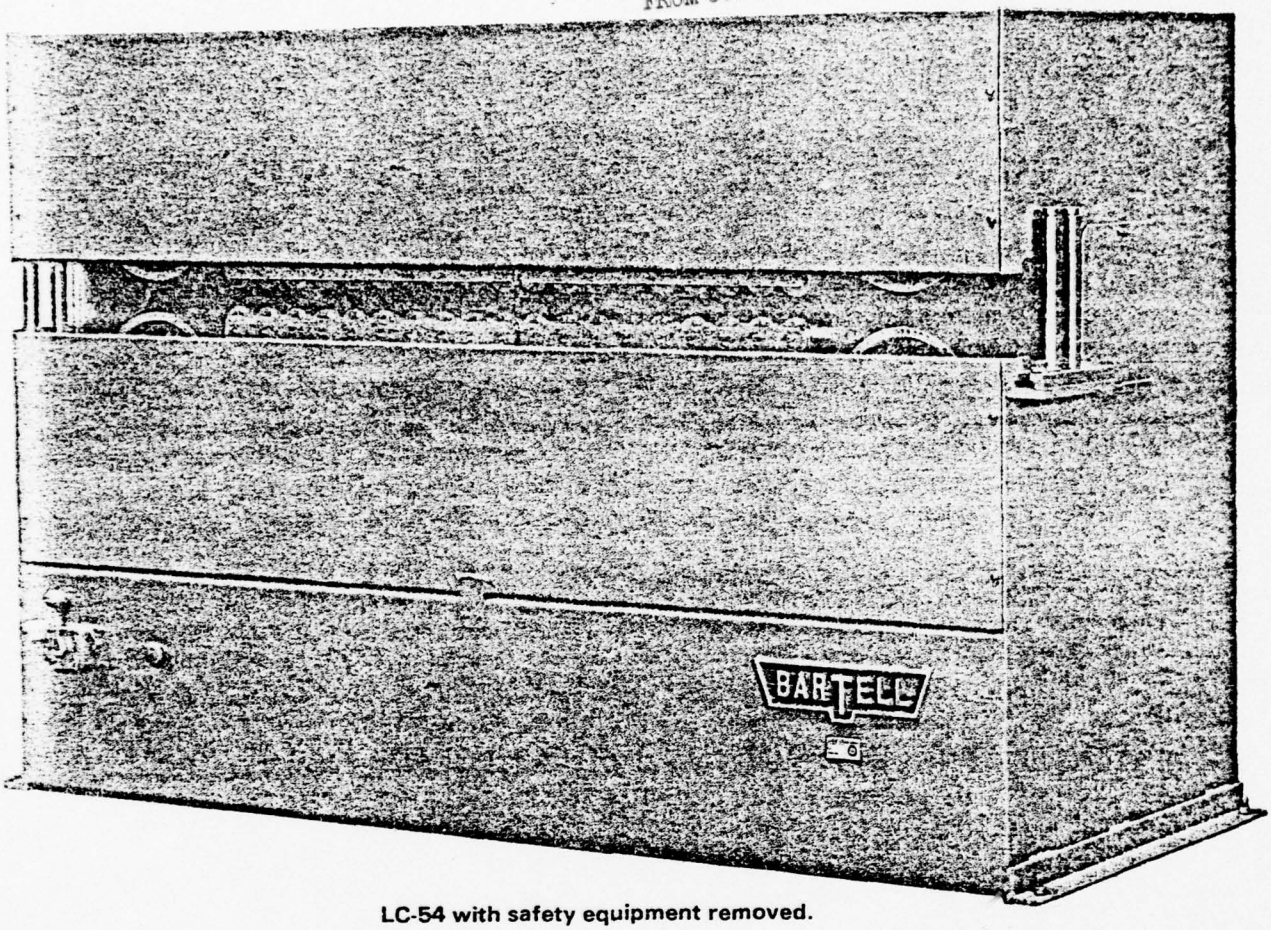
Other quality features:

- Maximum operating speeds of 800 and 1000 feet per minute.
- Poly-V type belts, each backed by 19 grooved rollers, equipped with ball bearings and grease fittings.
- Large end pulleys provide good traction and long belt life.
- Tread assemblies "float" on anti-friction supports and are air-actuated.
- Vertical guide rollers at cable entrance and exit are adjustable, feature ball-bearing construction.
- Power transmission is smooth and reliable, and includes worm-gear speed reducers and constant-velocity universal joints.

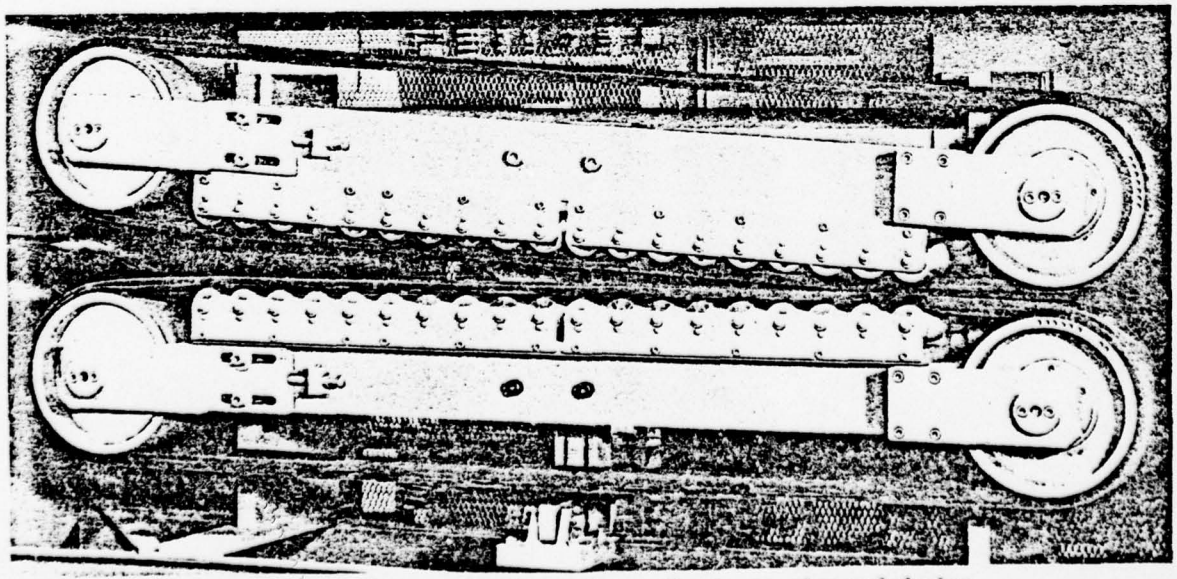
Controls

A manual valve opens and closes the tracks, and a pressure regulator adjusts the clamping force. Both controls are panel-mounted at the front of the machine.

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC



LC-54 with safety equipment removed.

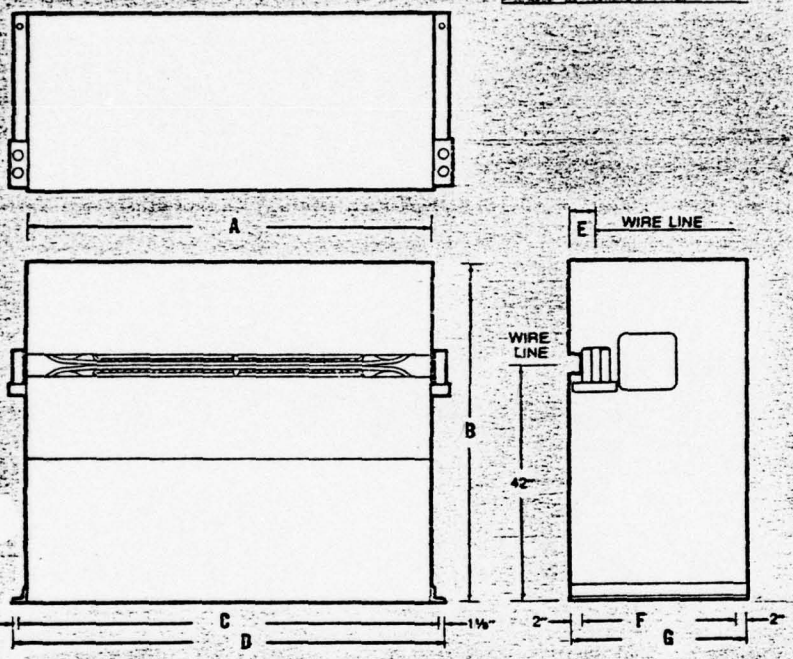


Upper track adjusts to various diameters by "tilting," as well as by opening and closing.

Dual worm-gear reducers provide positive trouble-free drive on Model LC-54 capstan.

Bartell Belt-type Linear Capstans





Model No.	A	B	C	D	E	F	G
LC-40.5 & LC-40.5-T	70½"	60"	73¼"	75½"	4½"	27"	31"
LC-54	95½"	64"	98¼"	100½"	6"	36"	40"

SPECIFICATIONS

	LC-40.5 & LC-40.5-T*	LC-54*
Compression Section Length	40½"	54"
Wire center-line elevation	42"	42"
Track Opening	0-4"	0-6"
Maximum operating speed	800 ft./min.	1000 ft./min.
Wire pull, at up to 400 ft./min.	800 pounds	2000 pounds
Wire pull, at maximum speed	400 pounds	800 pounds
Belt width	3½"	4½"
Belt material	½" of 60 Durometer Neoprene	½" of 60 Durometer Neoprene
Wire velocity at 1000 RPM of the input shaft with standard reduction	471 feet per minute	628 feet per minute

* Upper track has "Tilt" feature.

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

NS NATIONAL-STANDARD COMPANY

DOMESTIC OPERATIONS

ATHENIA STEEL DIVISION
Clifton, New Jersey

BARTELL MACHINE DIVISION
Rome, New York

BUCHANAN STEEL PRODUCTS DIVISION
Buchanan, Michigan
Havana, Illinois

CHENEY BIGELOW INC.
Weaverville, North Carolina

N-S MACHINERY DIVISION
Niles, Michigan

N-S WIRE DIVISION
Niles, Michigan
Akron, Ohio
Kansas City, Missouri
Mount Joy, Pennsylvania

PERFORATED METALS DIVISION
Carbondale, Pennsylvania

RAWLS DIVISION
Lima, Ohio
Oakland & South Gate, California

STRANDFLEX DIVISION
Oriskany, New York

STRIP STEEL, INC.
Fraser, Michigan

TIRE TEXTILE DIVISION
Columbiana, Alabama
Stillwater, Oklahoma

WAGNER LITHO MACHINERY DIVISION
Secaucus, New Jersey

WESTERN DIVISION
Los Angeles & Santa Fe Springs, California

WORCESTER WIRE DIVISION
Worcester, Massachusetts

WOVEN PRODUCTS DIVISION
Corbin, Kentucky

Dear William 6/16/7

FOREIGN SUBSIDIARIES

NATIONAL-STANDARD COMPANY OF CANADA, LIMITED
Guelph, Ontario, Canada

NATIONAL-STANDARD COMPANY, LIMITED
Kidderminster, England
Telford, England
Perth, Scotland
Llanelly, Wales

NATIONAL-STANDARD COMPANY (S.A.) (PTY.) LTD.
Uitenhage, South Africa

NATIONAL-STANDARD (S.A.)
Chambéry, France

w/o drive 8/15/80 est 1 May—1 24 2HP req'd C.T off. 400 FPM $2000# ~20wks ARO.

AFFILIATE

NATIONAL-STANDARD DUNCAN LIMITED
Bombay, India

• 8 HRS/day for 1 yr Belt Life
• Philips Cable Brantford Ontario still has or's belts

APPENDIX B

APPENDIX B

IDEALIZED CLAMP TRACTION DEVICE

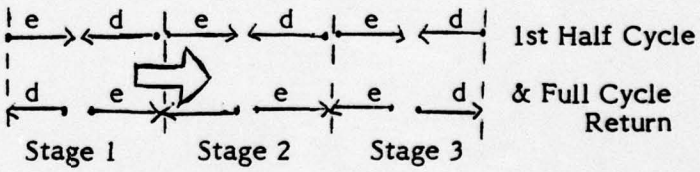
APPENDIX B

IDEALIZED CLAMP TRACTION DEVICE

- Configuration: Multiple Stage, Articulated Clamp, Reciprocating. (4-Point Contact)

- Operation:

(a) Articulated Clamps are engaged simultaneously along a length of cable by a set of linear actuators which force the clamp to pivot up against the cable surface. The remainder of the stroke forces the cable - under load - at up to 200 FPM. Reversal of the engaged clamp set linear actuators, causes the clamp assemblies to pivot back -- disengaging the clamp set for return to its starting position -- while a second set, in diametrial opposition, is engaged to continue the forward motion of the cable.

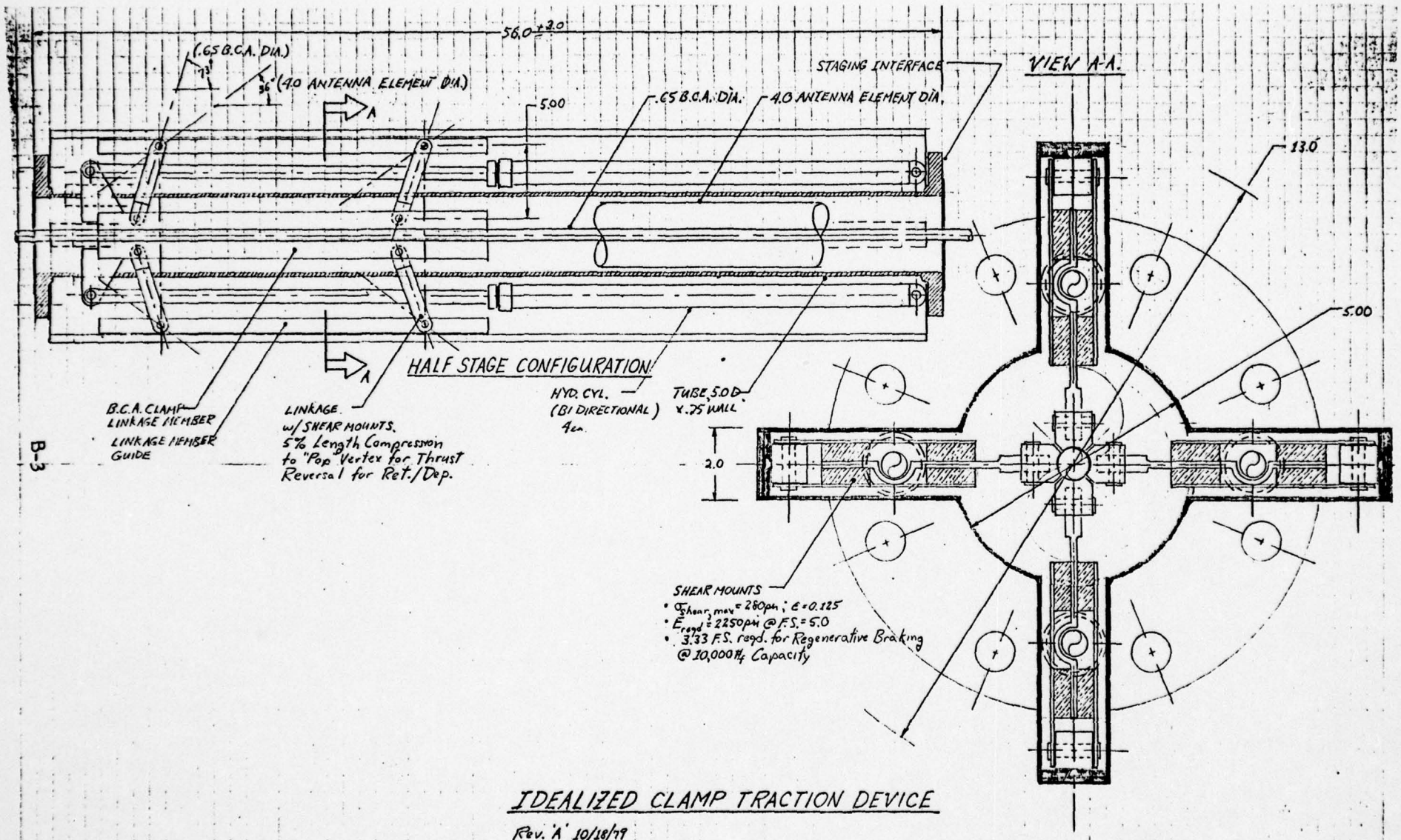


NOTE: The top arrows represents 4 ea clamps engaged and 4 ea clamps disengaged/stage.

The bottom arrows represent the return cycle of the above clamps.

(b) Reversal of cable motion (large arrow) is accomplished by overdriving "or popping" the pivot point linkages to reverse the engagement/disengagement clamp set in operation.

(c) Capable of handling up to 4" OD. Antenna Element.



B-3

IDEALIZED CLAMP TRACTION DEVICE

Rev. 'A' 10/18/79
W.R. RICHARDS

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

- Considerations:
  - (a) Stage synchronization is required -- including dynamic interstage balancing.
  - (b) μ variance susceptibility much less than the linear traction device due to the mechanical advantage of the pivot linkage $\}$.
  - (c) Dyn. Load Cap. directly proportional to length. Note qualif. by Test Data, Appendix G., and Load Cap. consideration per Appendix H.
  - (d) Contribution (Dyn. Load) of the Storage Assy. is not included.
  - (e) Configuration adaptable to seawater exposure.
  - (f) A single stage failure need not cripple functioning of the entire multiple stage config. -- <u>if</u> design allows for stage disengagement to the non-contact mode.
  - (g) Phase overlap by $\simeq 5 \rightarrow 15\%$ will be required to <u>assure</u> continuous motion w/o cable slippage.
  - (h) S.B. Noise generation limits per Appendix F.

1. Finding required PSID/stage # $3000\#_f$ dynamic load:

   Assume $400\#_f$/half stage to 100% peripheral contact around the cable

   or - $100\#_f$/half stage - single clamp @ $50\#_f$/linear ft., w/333# vertical force (normal force) provided @ $\mu_{min} = .333$

   or - ram force - 3/4" Dia piston area = .442 $in.^2$ and assume clamp distance = 2', w/2' (net) stroke

   $\therefore$ ($100\#_f$ net/.442 $in.^2$ = <u>212.06 psid reqd</u>)

2. Finding reqd Flow/Stage @ 200 FPM:

$$.442 \text{ in}^2 = Acs = .785 \left(\text{Bore/Cyl}^2 - \underset{.625}{\text{Rod/OD}^2}\right)$$

$\therefore$ Cyl Bore $\simeq$ 1.0"

or - .442 in.^{2}. A^*_{cs} x 24" stroke x 100 stroke/m in. = 1885 in.^{3}/min

= 816 GPM/Cyl x 4 = 18.36 GPM/Stage

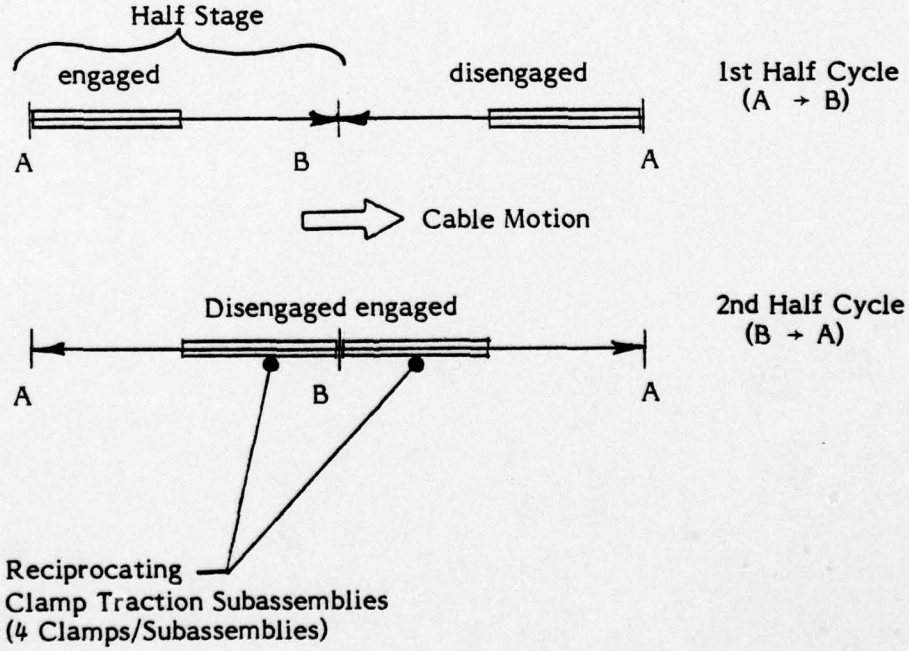
or - with 8 stages = 146.95 GPM

$$\therefore \quad HP_{reqd} = \frac{146.95 \text{ GPM} \times 212.06 \text{ psid}}{1714} = 21.02 \text{ HP}$$

@ 3000#$_f$
and 200 FPM

(Note that a stage = 8' lg for dyn. balance; @ 2' (net) stroke + 2' clamp distance)

or -



*Retrieve A_{cs} = .442 in.^{2}; Deploy A_{cs} = .785 in.^{2}

3. Finding Envelope Required @ 3000#$_f$ dynamic load:

(Refer to Figure 1)

@ $\bar{A}_{cs}$ = .46 ft^3 @ OD/ $\sqrt{2}$", x 4.66 ft/Half Stage", x 2", x 8 Stages

= <u>34.30 ft^3</u>

4. Finding Weight Required (@ 3000#$_f$ dynamic load)

a. Tube 5" OD x .25 wall = 3.93 in.^{2} x 12 x 67' x .3#/in.^{3} = 1582# !

$\therefore$ use Alum. @ 1/3rd wt - - - - - - - - - - - - - - - - - = 527#$_f$

b. Clamp Support Housing @ 4 ea

W/Housing A_{cs} = 1.13 in.^{2} + .98 in.^{2}, = 2.11 in.^{2}

or - - - - - - - - = 2.11 in.^{2} x 12 x 64' x .3# - - - - - = 486#$_f$!

$\therefore$ use Alum @ 1/3rd wt - - - - - - - - - - - - - - - - - = 162#$_f$

and w/4 ea Housings - = 486#$_f$

c. Top and Bottom Linkage Members (4 ea)

= .65 in.^{2} x 12 x 32' x .3 x 2 - - - - = 150#$_f$

d. Linkages - 2/Clamp Subassy (128 ea)

= 1.0# x 16/stage x 8 stages - - - - - - - = 128#$_f$

e. Hyd. Cyl. Rams (64 ea)

@ 1.25 OD x 1.00 ID x 24" Lg x .3 = 3.53#

w/.625 OD Rod 24" lg x .3 - - - - = 2.21#

+ Misc - - - - - - - - - - - - - - - - = <u>1.26#</u>

or - for 64 Cylinders, @ 7.00#$_f$/Cyl = 448#$_f$

f. Staging Flanges (16 ea)

@ 3/8" thk plate x 12.65 OD x .1 = 4.71#/Flg

and 16 ea plates - = $75\#_f$

$1814\#_f$

g. Misc - = + $186\#_f$

$2000.0\#_f$

h. Finding impact of Antenna Element Lump Size Reduction:

i. 3/18" linkages for 1.38" Dia Lump

Reqt = 8.125 OD vs 13.0 OD for 4" Lump

Tube OD = 2.00 or 2.5 x reduction - - - - - - - - = $317\#_f$

Clamp Support Housings wt reduction - - - - - - = $145\#_f$

Linkage Arm wt reduction - - - - - - - - - - - - = $32\#_f$

Staging Flgs wt reduction - - - - - - - - - - - - = $32\#_f$

$516\#_f$

(Vol Reduction = .39x, or 13.41 ft^3)

5. Finding Number of Components/Stage and Cost Estimate

Component	Hardware Cost Est.	No. of Components
• Hyd cylinders (8 ea) @ $80 ea	$ 640	8
• Linkages (16 ea) @ $25 ea	400	16
• Top and Bottom Members (16 ea)	400	16
• Tube, 5 in. OD x .25 wall (1 ea)	300 (alum.)	1
• Clamp Support Housings (8 ea)	400	8
• End Flanges (2 ea)	50	2
• Torsion Mounts (32 ea)	100	32
	$2290	83
	x 8 Stages	x8 Stages
	$18,330	664 Components
• Misc	1832	
• Factor-of-Safety @ 20%	3664	
	$23,816	

6. Stage Length Characterization:

a. The 2' Clamp, 2' Stoke has been selected for the following reasons:

- Cable Analysis Tests per Appendix G indicate that up to 733#$_f$/linear ft may be imposed on the 0.65 Dia. cable assembly without yield --if no bending is imposed. A 1' clamp (x 4 ea) would generate 400#$_f$/linear ft shear on the cable assembly; while a 2' clamp assembly provides 200#$_f$/linear ft on the cable assembly -- at half the reciprocating speed, and < 33% of the theoretical yield point of the cable assembly. Hydraulic cylinder sizing for > 2' Clamp/2' Stroke is untenable due to column buckling effects imposed on the cylinder rod.

b. If the operating pressure is doubled, the 400#$_f$/ half stage value would double, and the imposed shear load on the cable assembly would rise to 400#$_f$/linear ft -- with an operating margin-of-safety of 1.83. Although this appears high -- it should be noted that 100% peripherial clamping is maintained about the .65 Dia. cable assembly - reducing any distortion effects to cable geometry. The number of stages required could be reduced to 4.

7. Characterization of Structureborne Noise:

- Refer to Appendix F. 200 FPM appears to be the upper achievable limit - presupposing that 0.25% phase imbalance/mass balance.

APPENDIX C

APPENDIX C

IDEALIZED SINGLE DRUM CAPSTAN

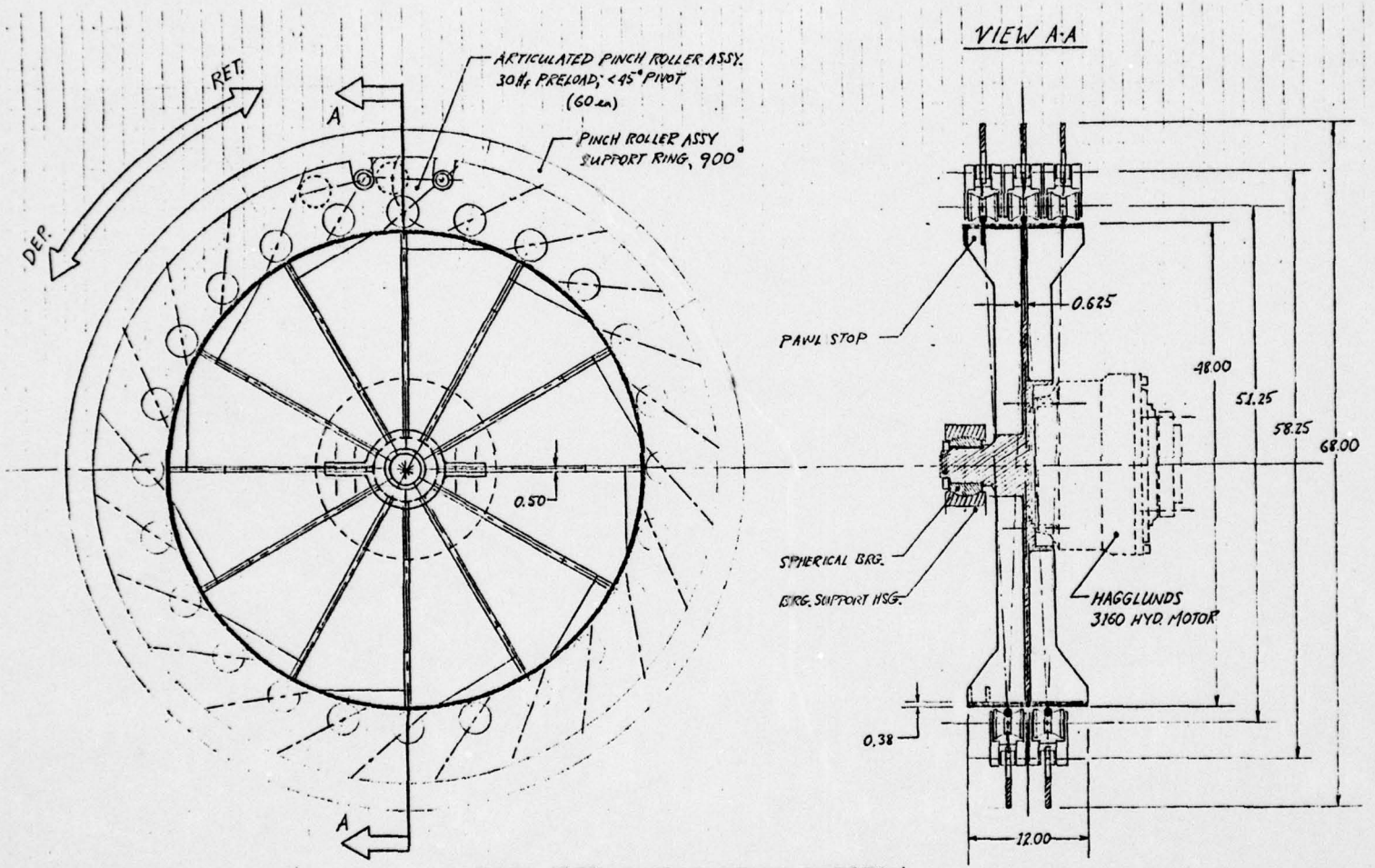
APPENDIX C

IDEALIZED SINGLE DRUM CAPSTAN

- Configuration: BRA-24 analogy, large P.D., with articulated Pinch Roller Assemblies in place of the driven roller assemblies.

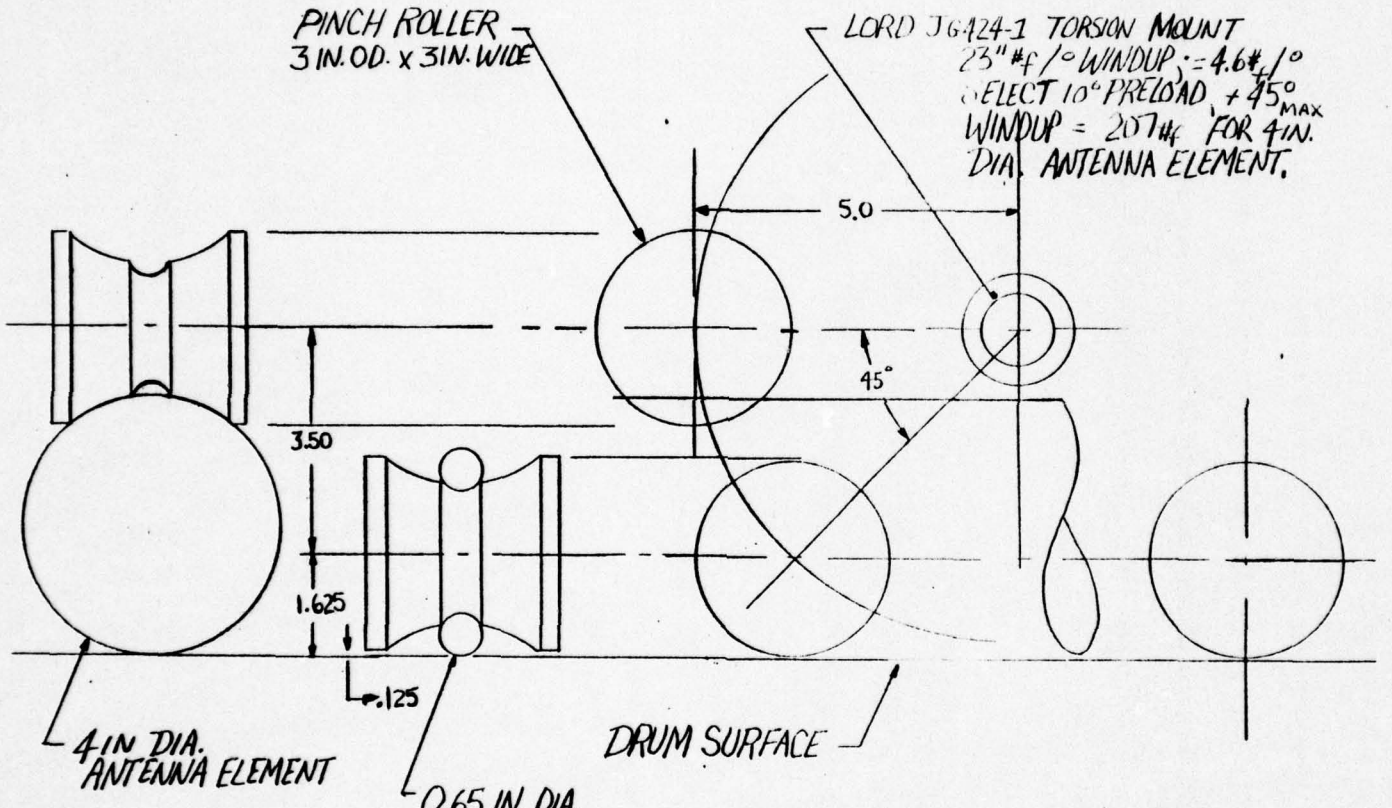
- Operation:
  (a) Similar to BRA-24.
  (b) Antenna Element Lumps up to 4" OD may be passed by having the Pinch Roller Assemblies pivot away from the capstan drum surface.

- Considerations:
  (a) Multiple Wraps >> required due to Euler Relation, are necessary to assure that the 100#/ft limitation is not exceeded.
  (b) Each wrap must be fully restrained by P.R. Assemblies to "force" the B.C.A. to move transversely across the capstan surface.
  (c) μ variance dictates the amount of Pinch Roller Assembly preload required to develop deployment forces.
  (d) Dyn. Load Cap. directly proportional to Circumference x No. Wraps. Note qualif. by Test Data Appendix G, and Load Cap. consideration per Appendix H defining B.C.A. limitations and operational envelope requirements.
  (e) Contribution (dyn. load) of the Storage Assembly is not included.
  (f) Configuration adaptable to seawater exposure.

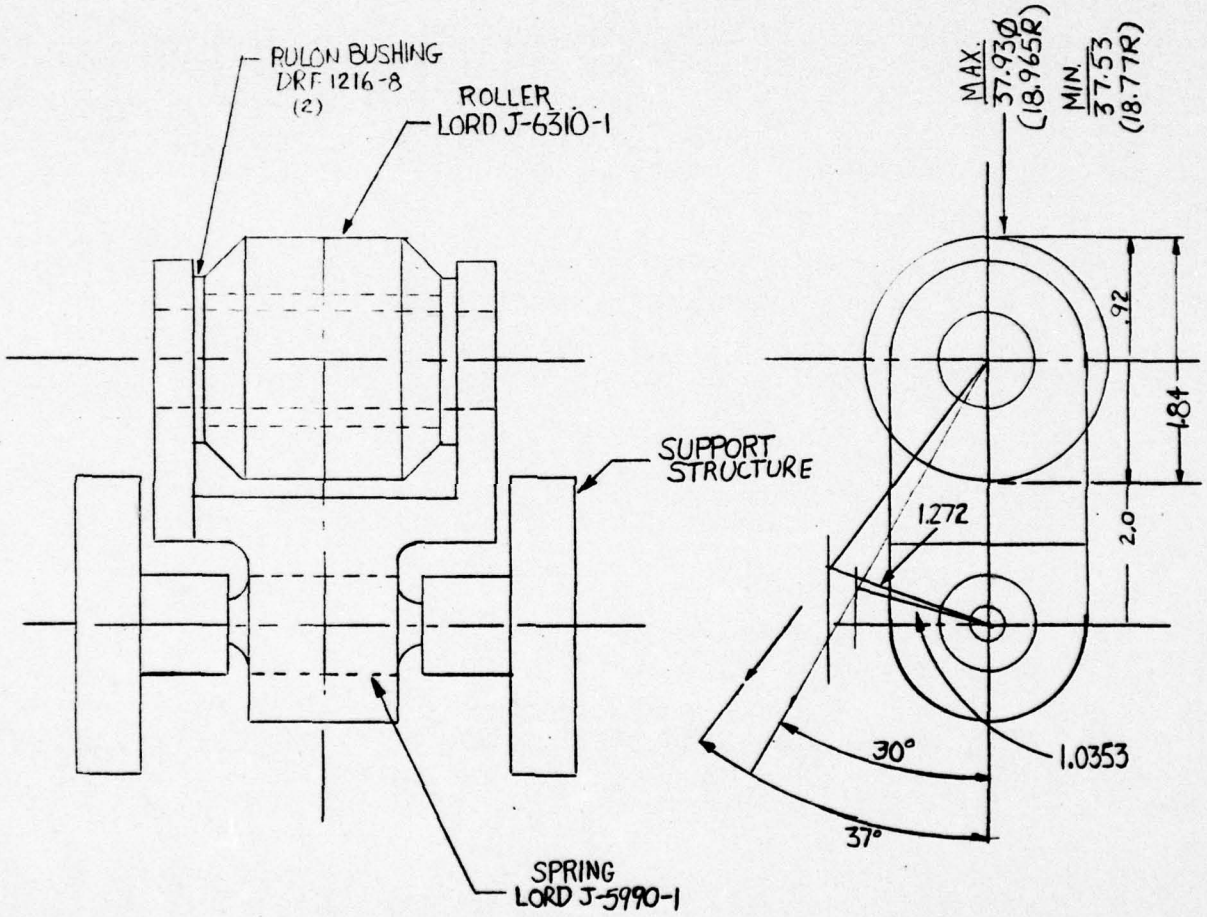


IDEALIZED SINGLE DRUM CAPSTAN

Rev 'A' 10/18/79
W.R. Richards.



FIGURE; PINCH ROLLER CHARACTERIZATION
10/18/79
W.R. RICHARDS



CHETSA PUNCH ROLLER CONFIGURATION
-(EXAMPLE ONLY)-

1. Finding Estimated Weight per Assembly and Cost Estimate:

Component	Hardware Cost Est	Weight, $\#_f$
• Hydraulic Motor, 3160	$ 4,000	639.0
• Capstan Drum, .38 thk	6,000	206.3
- Plate, .625 thk	-	352.3
- Stiffeners, .50 thk	-	266.0
- Pawl Flanges	-	93.6
• Hyd. Motor Interface Plate w/	-	75.4
- Stiffener Ring	-	22.6
- Hub and Shaft	-	50.0
• Bearing Support	800	75.0
• Bearing, 3" Kamatics	4,000	25.0
• Pinch Roller Assemblies (60 ea)	5,000	300.0
• Pinch Roller Support, 900°	1,200	76.6
• Misc	1,060	115.5
	$22,660 ±25%	2300.0 $\#_f$ ±10%

2. Finding Envelope Required:

= .785 (68 in. OD)^2 x 12 in. = 43,558 in.^{3}

= <u>25.21 ft^3</u>

3. Finding Number of Components Required per Assembly:

	Number
• Drum, Split Halves	2
• Bearing Support	1
• Bearing, w/Nuts	3
• Hydraulic Motor	1
• Pinch Roller Supports	5
• Pinch Roller Assemblies	60
• Motor Interface Plate w/Ring, Hub and Shaft	3
	74

4. Characterization of Hydraulic Drive:

Requires 3000#$_f$ @ 2' Radius, 200 FPM

Goal 6000#$_f$ @ 2' Radius, 400 FPM

a. 3160 Characteristics - 639#$_f$ wt; Gal/Rev = .896; 275'#/100 psi

@ 3000#$_f$, 200 FPM = 6000'#/275'# per 100 psi = 2182 PSI

& @ 200 FPM/4' Dia x π = 15.92 RPM x .896 Gal/Rev = 14.36 GPM

or - as $\frac{\text{PSI x GPM}}{1714 \times \eta_o} \simeq \frac{18.54}{.93 \times .93} \simeq$ 21.0 HP

b. 4170 Characteristics: - 1145# wt; Gal/Rev = 2.44; 563.6'#/100 PSI

@ 3000#$_f$, 200 FPM = 6000'#/563.6'#/100 PSI = 1065 PSI

& @ 200 FPM/4' Dia x π = 15.92 RPM x 2.44 Gal/Rev = 38.86 GPM

or, as $\frac{\Delta\text{PSI x GPM}}{1714 \times \eta_o} = \frac{24.136}{.93 \times .93} =$ 21.05 HP

(Note that this would also add 506#m wt to the capstan subsystem.)

c. Employing Two-Speed Opn'l Mode from 6000#$_f$ @ 200 FPM to 3000#$_f$ @ 400 FPM, doubles the initial required operating ΔP to 4364 PSI; and HP to 55.8

d. Both drives are capable of operation with Two-Speed Valves.

5. Per Appendix I - Capstan Characterization, Finding No. of Wraps:

@ 3000#$_f$, Euler Relation requires 339° for $\mu = 0.25$,

100#$_f$/ft Cable criteria requires 859.2° (or, 2.39 wraps)

& @ 6000#$_f$, Euler Relations requires 408° for $\mu = 0.25$

100#$_f$/ft Cable criteria requires 1718.4° (or, 4.77 wraps)

- Per Appendix G, Cable Analysis, % elongation w/12" P.D. Capstan = 5.4%; with a 48" P.D. = 1.35%, & % elongation @ 100#$_f$/linear ft = 1.69%

  (potential to go to 200#$_f$/linear ft exists !)

- If lumps could be reduced to 2.0", the depth of the Capstan Assy could be reduced by 6.0 inches, and the envelope requirement reduced by 50%.
- If cable load per linear ft could be raised to 200#$_f$, the depth of the Capstan Assy could be reduced 4.0 inches, and the envelope requirement reduced by 33%.

6. Structureborne Noise: Comparison to Linear and Clamp Traction Mechanisms

- Max 31.84 RPM = 1.88 sec/Cycle (Capstan)
  @ 400 FPM

  Max 256 RPM = 0.23 sec/Cycle (Linear Traction)
  @ 400 FPM

  Max 200 FPM = 0.60 sec/Stroke (Clamp Traction)
  @ 2' stroke

  or 1.20 Sec/Cycle

  ∴ Inherently advantageous, from standpoint of generation of structureborne noise. Refer to Appendix F for additional details.

7. Torque loss due to Antenna Element Transfer (4 in. OD x 4 ft Long)

- As a lump will develop a max. 45^{o} windup, this yields a $207\#_{f}$ contact loading. Refer to Figure 2.
- Increased torque (loss) due to Antenna Element Passage

$$F_{PR} \times R_{PR} = .10\ \mu \text{ est} \times 207\#_{f},\ N \times \frac{.625\text{" Shaft Dia}}{2} = 6.47\text{"}\#$$

$$\& \underset{\text{Driving}}{\text{PR}} \times RPM_{PR} = \tau_{\substack{\text{Loss} \\ \text{Capstan} \\ \text{Drum}}} \times RPM_{\substack{\text{Capstan} \\ \text{Drum}}}$$

$$\therefore\ \tau_{Loss} = 16.0 \times \tau_{P.R/roller}$$

As 8 Rollers per 4 ft circumferential Dist.,

$$\therefore\ \tau_{Loss} = 16.0 \times \tau_{P.R.} \times 8\ \text{Rollers}$$

L. D. = 828.16"#, = 69.1'# torque loss due to Antenna Element Passage

APPENDIX D

APPENDIX D

IDEALIZED LAMINAR FLUID DEVICE

APPENDIX D

IDEALIZED LAMINAR FLUID DEVICE

- Configuration:
  (a) A high viscosity fluid under laminar flow conditions is employed to generate viscous drag forces on the B.C.A. while within the flow tube (or Conduit).
- Operation:
  (a) Direction of Flow, GPM, Viscosity and Vel_{rel} determine the net Drag force generated/unit length of Conduit. End containment of the Viscous Fluid is achieved by use of dynamic, variable dia. seals which permit passage of the antenna elements, but contain the viscous fluid.
- Considerations:
  (a) Flow head losses are high
  (b) A pump recirculation source must be provided for the viscous fluid
  (c) μ variance not relevant.
  (d) Dyn. Load Cap. directly proportional to length. Note qualif. by Test Data, Appendix G and Load Cap. consideration per Appendix H defining B.C.A. limitations and operational envelope requirements.
  (e) Contribution (Dyn. Load) of the Storage Assembly is not included.
  (f) Configuration intended for seawater exposure.
  (g) Spec. of viscous fluid required and testing is essential to verify predicted performance.

1. a. $@D_{HYD} = 2$; 0.65 Dia Cable $Vel_{reqd} = 6'/sec$, $Vel_{abs} = 9.33'/sec$

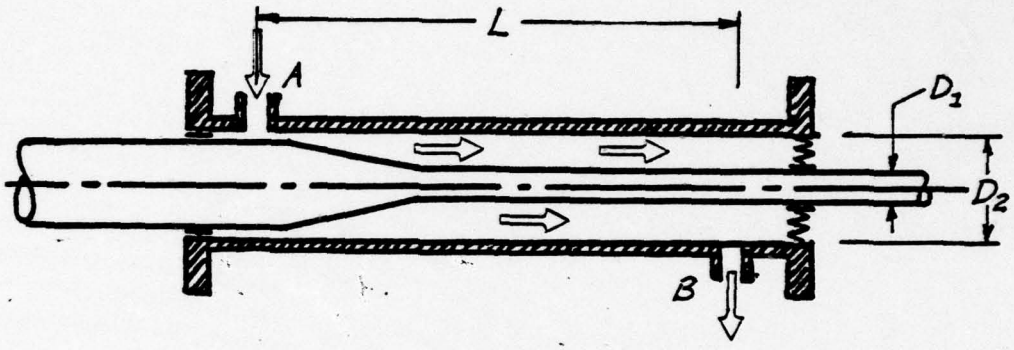
$$Re_{reqd} \text{ for } 50\#_f/ft = \left(\frac{1.32}{6.57}\right)^2 = .0408$$

2/28
WRR

APPENDIX D

IDEALIZED LAMINAR FLUIDIC DRIVE

- Configuration:



- Operation: Employs viscous drag effects of a visco-plastic fluid pumped from A ⇆ B to generate cable driving force, where:

- $\text{DRAG, \#}_f/\text{FT} = \dfrac{C_D \rho \, Vel^2 \, A_{\text{CABLE/LINEAR FT.}}}{2 g_c}$

- $\Delta P, \#_f/\text{FT}^2 = \dfrac{2.15 \times 10^{-4} \times f \times \rho \times L \times Q^2}{d_{HYD}^5}$

- $d_{HYD} = D_2 - D_1$

- Fluid Viscosity ≥ 10,000 cs

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

$$\mu_{reqd} = \downarrow 80\#m/ft^3 \downarrow_{(est)} \times \frac{9.33'/sec \times 2"/12"/ft}{.0408}$$

$$= \underline{3049\#m/ft\text{-}sec}$$

as 1 cp = .00672#m/ft-sec

& 1 cs = 1 cp/ρ

$\therefore$ μ_{reqd} = 56715 cs

b. • $Q, GPH = \frac{219,500 \times Dia_{HYD}}{Sp\ Gr \times \mu \times cs \times L} \frac{4 \times PSI}{}$

& setting Dia_{HYD} = 2, PSI @ 133 PSI/ft

Sp Gr @ 1.282 & μ = 56,715 cs

$\therefore$ Q = 107.07 GPM

• Check, using Streamline Flow Calculator

@ Bore = D_{HYD} = 2, Sp Gr = 1.282 & Q = 107.07 GPM,

$\therefore$ Δ PSI/ft indicated = 133

2. a. D_{HYD} = 2; 0.65 Dia Cable Vel_{rel} = 6'/sec, Vel_{abs} = 9.33'/sec

Re_{reqd} for 25#/ft (CD = 3.285) = $\left(\frac{1.328}{3.285}\right)^2$ = .1634

or, μ_{reqd} = 762#m/ft-sec

$\therefore$ μ_{reqd} = 14,179 cs

b. • $Q,^* GPH = \frac{219,500 \times Dia_{HYD}}{Sp\ Gr \times \mu \times cs \times L} \frac{4 \times \Delta PSI}{}$

assuming Q remains the same as in 1b, Δ PSI $\alpha \mu$, or

$\therefore$ Δ PSI/ft = 133/4 = 33.2

- Check using Streamline Flow Calculator

$\therefore$ Δ PSI/ft $\simeq$ 34

3. a. Finding Reqd HP @ 2500#$_f$ & 200 FPM, 0.65 Dia Cable for 2b

$$\frac{33.2 \text{ PSI/ft} \times 100 \text{ ft} \times 107.07 \text{ GPM}}{1714} = \underline{207.4 \text{ HP}}$$

4. a. @$_{HYD}$ = 2; 1.00 Dia Cable, Vel$_{rel}$ = 6'/sec Vel$_{abs}$ = 9.33'/sec

$$Re_{reqd} \text{ for } 50\#_f/\text{ft} = \underset{(C_D = 4.26)}{\frac{1.328}{}^2} = .0972$$

$$\mu \text{ reqd} = \frac{80\#\text{m/ft}^3}{\text{(est.)}} \times \frac{9.33'/\text{sec} \times 2"/12"/\text{ft}}{.0972}$$

$$= 1280\#\text{m/ft-sec}$$

$\therefore$ μ reqd = 23,806 cs

b. Q^*, GPH = $\frac{219,500 \times \text{Dia}}{\text{Sp Gr} \times \mu \times \text{cs} \times L}$ HYD $\frac{4 \times \Delta \text{PSI}}{}$

Setting Dia, HYD = 2, Δ PSI @ 68 PSI/ft

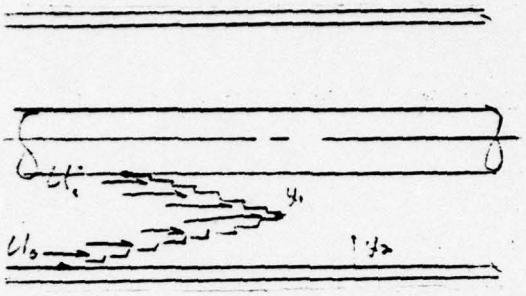
Sp Gr = 1.282 & μ = 23,806 cs

$\therefore$ Q $\simeq$ $\boxed{128.5 \text{ GPM}}$

Finding Reqd HP for 2500#$_f$ & 200 FPM, 1.00 Dia Cable for 4b

$$\frac{68 \text{ PSI} \times 50' \times 128.56 \text{ or M}}{1714} = 237.4 \text{ HP}$$

5. Assuming that analysis 1 → 4 in error due to $\bar{Q}$ considerations; @ μ_{cs} = 56715; D_{HYD} = 2 (Ref. 1a).



	Level	$Dia^2_{i^{th}}$ $Dia^2_{i-1^{th}}$	x Vel x 2.447	= Q_i
Vel. Profile	1	.80 = .64 - 42	@3.33'/sec	= 1.96
where $\mu f_{cs} = \frac{\tau}{du/dy}$	2	.90 = .81 = 64	4.33	= 1.80
& μf_{cs}, τ = const	3	1.00 = 1.00 = 81	5.33	= 2.48
	4	1.10 = 1.21 - 1.06	6.33	= 3.25
∴ du/dy = const	5	1.20 = 1.44 - 1.21	7.33	= 4.12
& y, equals y_2	6	1.30 = 1.69 - 1.44	8.33	= 5.10
	*-7	1.40 = 1.96 - 1.69	9.33	= 6.16
	8	1.50 = 2.25 - 1.96	8.33	= 5.91
	9	1.60 = 2.56 - 2.25	7.33	= 5.56
	10	1.70 = 2.89 - 2.56	6.33	= 5.11
	11	1.80 = 3.24 - 2.89	5.33	= 4.56
	12	1.90 = 3.61 - 3.24	4.33	= 3.92
	13	2.00 = 4.03 - 3.61	3.33	= 3.18
	14	2.10 = 4.41 - 4.03	2.33	= 2.41
	15	2.20 = 4.84 - 4.41	1.33	= 1.40
	16	2.30 = 5.25 - 4.84	.33	= .36
	OD_{Bore} = 2.40			= 57.216 GPM

∴ Using Laminar Flow Calculator:

O.D. Bore = 2.40; μ_{cs} = 56715 & ΔPSI/ft = 33.3;

$$HP_{reqd} = \frac{57.216 \text{ PSI} \times 33.3 \text{ PSI/ft} \times 60 \text{ ft} \times 57.2 \text{ GPM}}{1714}$$

$$= 66.5 \text{ HP !}$$

6. Summary

- Analysis characterized for 0.65 Dia cable in 1.65 ID conduit of 60 ft length.
- Preliminary analysis indicates feasibility of development of viscous drag device capable of 200 FPM and 3000#$_f$ dynamic loading capability.
- Analytical Basis:

  Drag Coefficient, cd = 6.57

  Drag Force, F = 50#$_f$ linear ft cable

  Reynold N$^{o}_{=}$, Re = .0408

  ABS Flow Vel = 9.33 ft/sec

  Rel Flow Vel = 6.00 ft/sec

  HYD Dia, DH = 2.00 in.

  Fluid Flow, Q = 107.1 ÷ 2, ($\bar{Vel}$) = 53.6 GPM

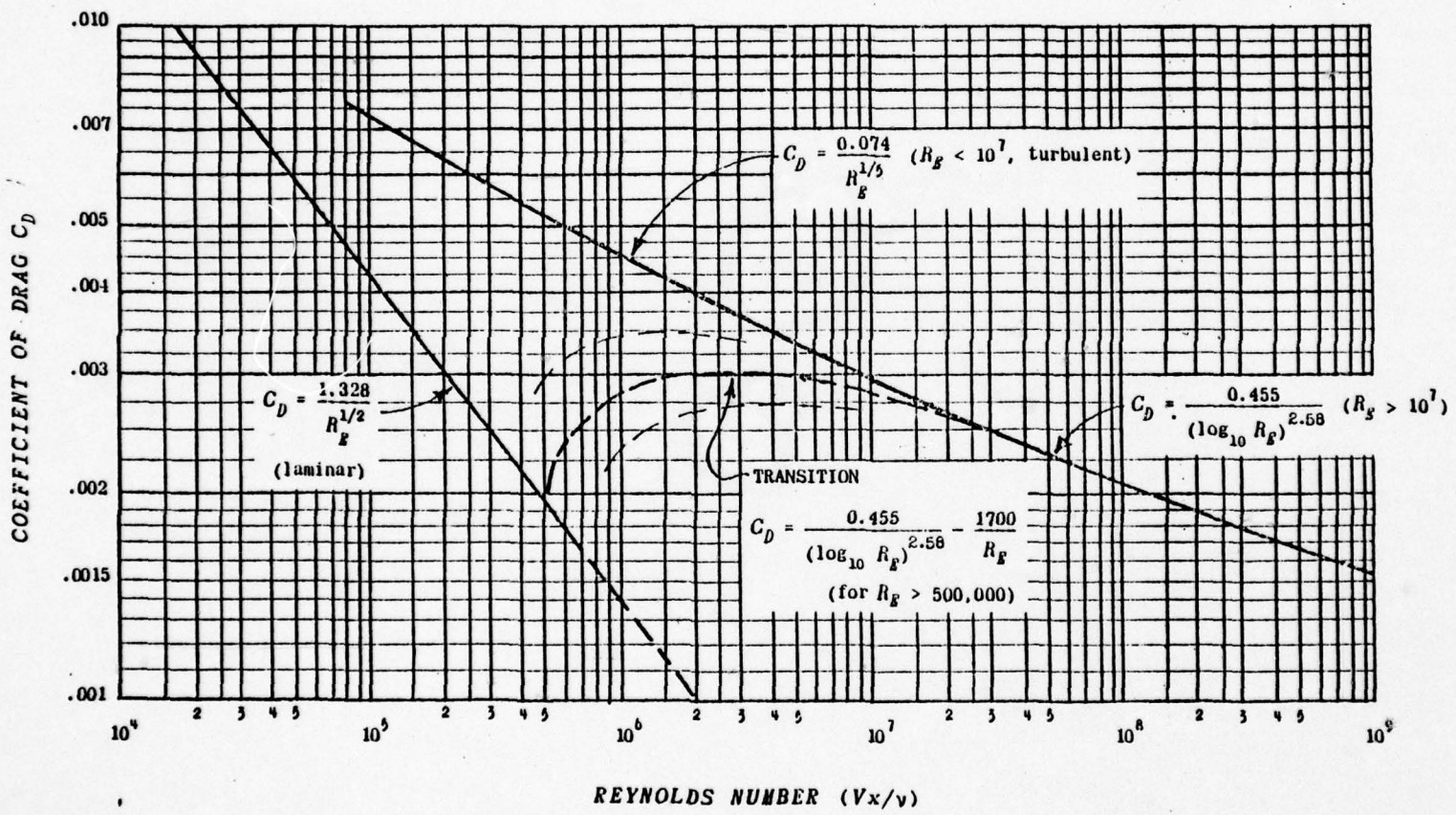
  Pressure Drop ΔP = 33.2 PSI x 60/linear ft conduit

  Reqd Horsepower, HP = 66.5 (For 60 ft conduit)

  Reqd ABS viscosity = 3049# m/ft sec

DIAGRAM G

DRAG COEFFICIENTS FOR SMOOTH, FLAT PLATES



APPENDIX E

APPENDIX E

IDEALIZED DIRECT WINDUP

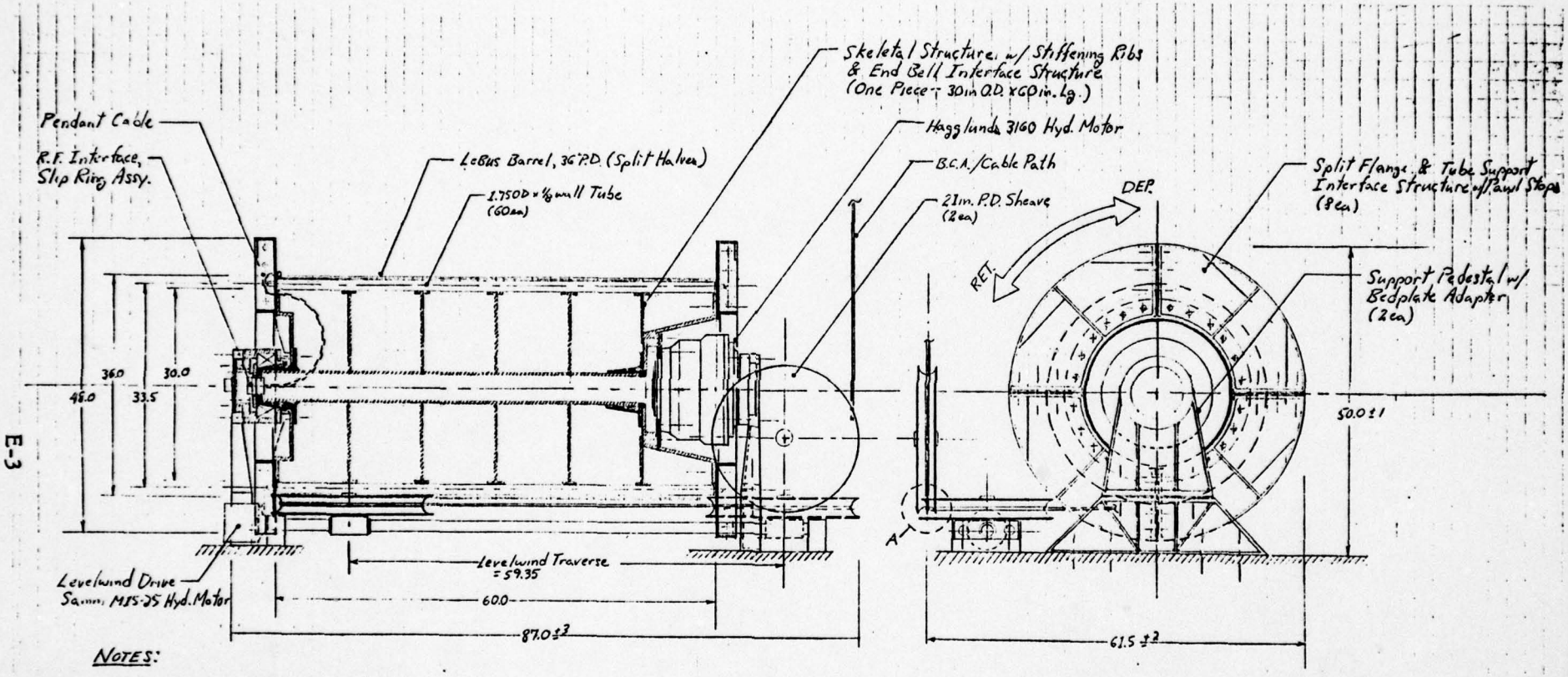
APPENDIX E

IDEALIZED DIRECT WINDUP

- Configuration:
  (a) Storage Assembly w/Levelwind.
- Operation:
  (a) Conventional winch operation.
- Considerations:
  (a) As Antenna Element lumps destroy levelwind -- can only be located on the outer wrap!
  (b) The Configuration should minimize the No. of wrap layers -- thereby maximizing B.C.A. Scope length amenable to Lump placement.
  (c) μ variance susceptibility is very low.
  (d) Dyn. load capacity inversely proportional to Circumference of Wrap Layer x Del. Torque of S.A. Drive. Note qualif. by Test Data Appendix G, and Load Cap consideration per Appendix H. Appendix I also applies.
  (e) Configuration adaptable to seawater exposure.
  (f) Levelwind will be required in order to minimize B.C.A. loading.

Characterization of Direct Windup:

1. Proper cable handling requires a Levelwind to assure support loading of the cable/elements is optimized
   - Lumps destroy levelwind traversing
2. Vol/Envelope:
   - Envelope of Direct Windup Assy = 70.14 ft^3
     Envelope of Dep. Aid Mech Assy = 6.40 ft^3
     Envelope of Levelwind Assy = 10.0 ft^3
     86.54 ft^3



NOTES:

(1) The Vertical Idler Sheave would not be required if the Direct Windup Assembly were oriented vertically.
(2) Accel/Decel., Cable Posn. Sensor Vlv. not shown.

IDEALIZED DIRECT WINDUP ASSEMBLY

Rev. 'A' 10/29/79 W.P. RICHARDS

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

3. Weight Estimate:

1.	Skeletal Structure w/Stiffening Ribs and End Bell Interface Str		
*	- Stress Tube -- 5" OD x .25 Wall x 4'3" Lg @ 12.68#/ft		54#
*	- Motor End Bell @ $\overline{20}$" OD x 12" lg x .5 thk		240#
*	- Bearing Support End Bell 24" OD x 3" lg x .5 thk		100#
*	- Tube Adapter Elements x 2		76#
	- Motor Mt Adapter Ring 18" OD x .75 thk		57#
*	- Stiffening Ribs 30" OD x .25 thk x 5		300#
2.	Split Flange Units 48" OD x 24" ID x .38" thk x 8		480#
3.	LeBus Barrel Support Tubing @ 2.169#/ft x 60		650#
4.	Bearing -6", Tapered		50#
5.	Bearing Support Housing		75#
6.	Support Pedestal x 2		160#
7.	Bedplate, Adaptive x 2		200#
8.	Hyd Motor, Hagglunds 3160		639#
9.	21 in. P.D. Sheaves x 2		90#
*10.	Levelwind Carriage Assy		250#
*11.	LeBus Barrel		300#
12.	Misc @ 200#		200#
			3921#
	Adj for Lightweight Technology, less		1343#
	Adj for Dep Aid Mechanism, plus		318#
		Net	2896#

*Must be Aluminum, 6061-T651 or equivalent

4. HP_{reqd}:

Refer to Appendix C; = 21.05

RPM_{Max} = 15.92

5. μ_{reqd}:

Refer to Appendix C; = .19

- This assumes that the imposed loading on the cable WRT τ & σ_c is identical to the Single Drum Capstan
- If we get a lower μ, τ is reduced.

6. Levelwind Requirements:

- Use LeBus Starting and Reversal Ramps with specified Flange Spacing
- Use simple direct-coupled drive such that 1 Drum Revolution equals traverse increment equal to one cable diameter
  - Ball Screw w/Carriage Assy
  - Timing Pulley w/Sprockets
  - End Bearing and Supports
  - Structural Support Frames
- Alt -- Direct Coupled Hyd Motor w/Accel. Prop. Flow Valve, Sensor to Sense Cable Position
  - Ref. AN/SQR-19 Proposal/UCHS Proposal

7. Additional Deployment Transfer Mechanism Requirements:

- As no cable containment, a small Transfer Mechanism having $400 \rightarrow 600\#_{f\ max}$ (and perhaps as little as $100\#_f$) is required to operate for:

$$\frac{1000\ ft}{200\ FPM}\ Scope_{est} = 5\ minutes$$

to achieve approx $600\#_f$ drag.

Note -- that @ reduced ship SOAs, in order to assure a minimum $100\#_f$, that the Transfer Mechanism would have to operate longer!

8. Major Advantages:

- Extreme Simplicity
- Very Low Engr. Dev. Risk
- The major Vol & Wt related components of the DRSS system -- i.e., Transfer Mechanism & Storage Assembly are combined into one system

9. Dev. Items:

- Are "Lumps" capable of being "located" such that they reduce levelwind upset?
  - can they be removed?
  - can we handle connectors 1" x 12"?
- Design of the S.A. Structure such that the piece-parts can be brought into the Pressure Hull thru a 26" Manhole!

The above items should be addressed at some later date.

APPENDIX F

APPENDIX F

STRUCTUREBORNE NOISE ANALYSIS

APPENDIX F

STRUCTUREBORNE NOISE ANALYSIS

1. Derivation of relationship for Structureborne Noise:

$x = A \sin(\omega t)$

where x = Displacement, meters

A = Amplitude

$\sin(\omega t)$ = Periodic, steady-state recurrence

$= 2\pi f_{Hz}$

$\therefore \quad \dot{x} = A\omega \cos(\omega t)$

& $\ddot{x} = -A\omega^2 \sin(\omega t)$

& $|\ddot{x}| = |A\omega^2|$ (1)

2. By ISO Standard vibration definition*:

$AdB = 20 \log (\ddot{x}/a_o)$

where $a_o = 10^{-5} m/sec^2$ or $10^{-3} cm/sec^2$

3. Derivation of AdB curve expression per NUSC SKA-55250.

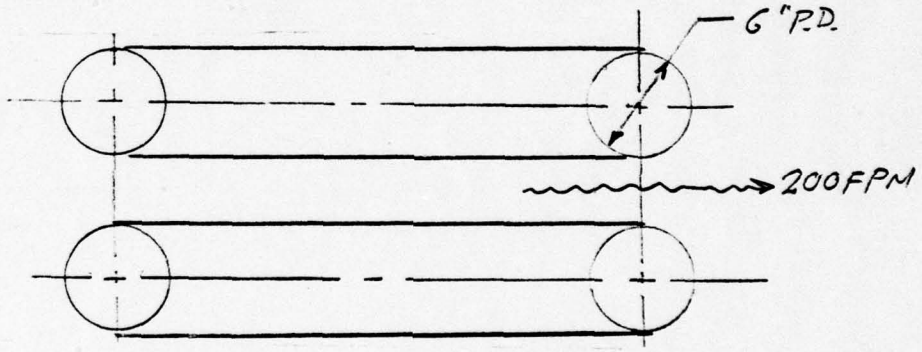
$$AdB = 60 \underset{1\ Hz}{\overset{100\ Hz}{/}} + 10(\log X_{Hz} - 1) \underset{10.0\ Hz}{\overset{100\ Hz}{/}} + 6.25(\log X_{Hz} - 3.2) \underset{1,600\ Hz}{\overset{10,000\ Hz}{/}}$$

*Secrets of Noise Control by A Thumann P.E. & R.K. Miller, The Fairmont Press, Inc. 1977

4. Derivation of allowable Amplitude @ X_{Hz}

		AdB	$(2\pi f)^2$	X	A, meters	A, in
1 Hz	=	60	39.48	.01	2.53×10^{-4}	.00997
2 Hz	=	60	157.91	.01	6.33×10^{-5}	2.45×10^{-3}
10 Hz	=	60	3948	.01	2.53×10^{-6}	9.96×10^{-5}
100 Hz	=	70	394784	.032	8.11×10^{-8}	3.19×10^{-6}
1600 Hz	=	70	1.001×10^{8}	.032	3.17×10^{-10}	1.25×10^{-8}
10,000 Hz	=	75	3.9118×10^{9}	.056	1.42×10^{-11}	7.94×10^{-1}

5. Evaluation of Traction Belt Mechanism Limitations:



@200 FPM, = 3.33' sec/1.57 circum = 2.12 Hz

∴ Per (4), allowable amplitude equals .00245 in.

Note, that @ 400 FPM amplitude equals .00061 in.

6. Evaluation of Reciprocation Clamp Traction Mechanism Limitations:

(a) $Fxt = m_{\substack{\text{piston} \\ \text{elements}}} \times \Delta Vel^{\uparrow\downarrow}_{\substack{\text{piston} \\ \text{elements}}}$

where F = reversal force required, reacted into the main structural mass of the associated configuration per unit length

(b) Assuming 3.33'/sec (200 FPM) driving vel, 25#m piston subassy recip. element group wt, and a "smooth" reversal occurring over 0.20 sec out of a 1.0 sec half cycle

$$\therefore F \times .20 = \frac{25.0\#m}{386\#m/\#_f \text{in./sec}^2} \times (3.33'/\text{sec} \times 2 \times 12"/\text{sec})$$

Or $F = 25.88\#_f$

(c) Assuming that every two sets of reciprocating element groups are symmetrically opposed, with a phase imbalance equal to .25%, w/associated configuration = 100#m

$$25.88\#_f \times .25\% = \frac{100\#m}{386\#m/\#_f \text{in./sec}^2} \times (a)$$

$\therefore a = .00635 \text{m/sec}^2$ @ 200 FPM (0.5 Hz)

& $a = .01270 \text{m/sec}^2$ @ 400 FPM (1.0 Hz)

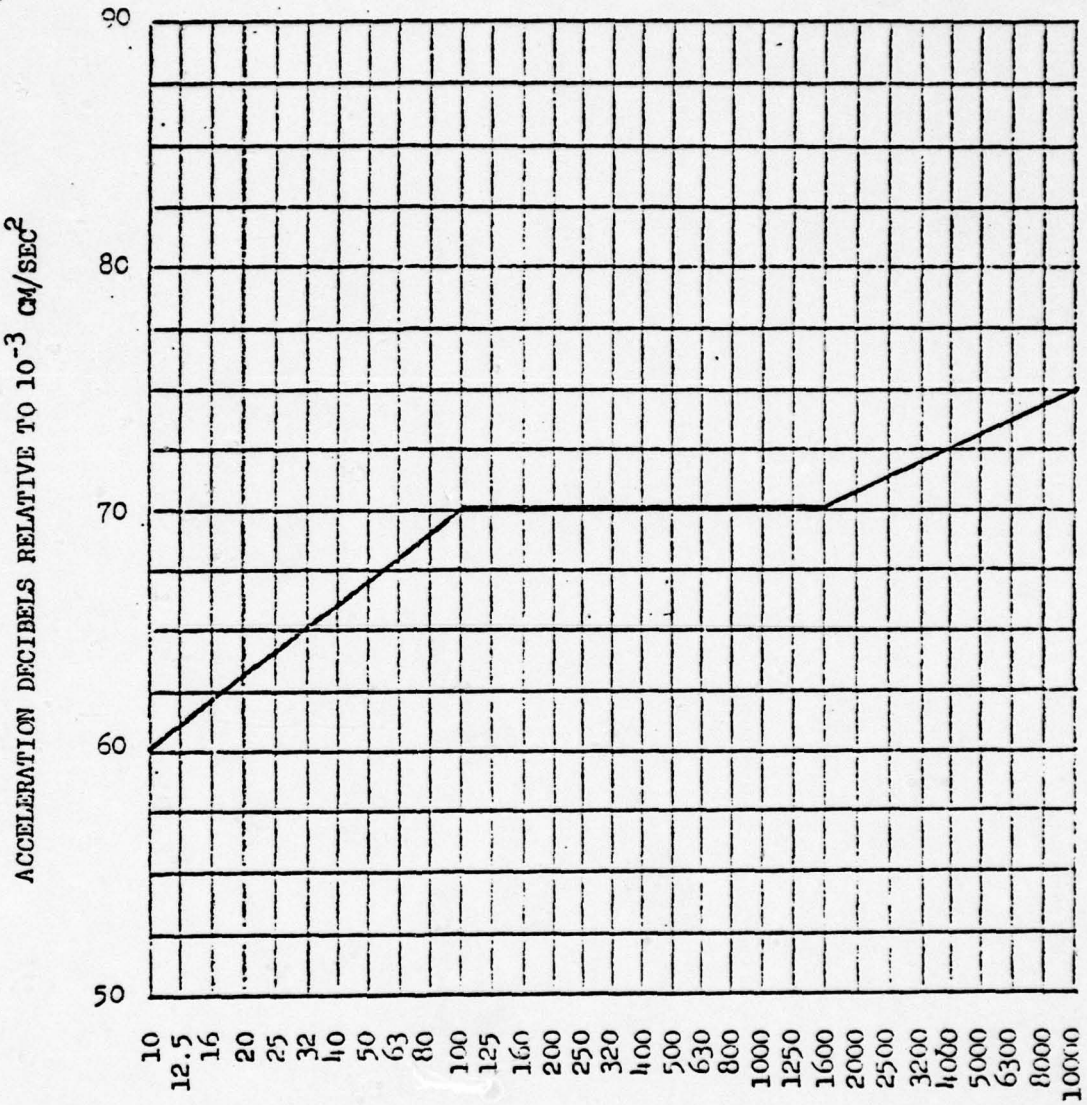
(d) Finding 'a' allowable from (2)

i @ 0.5 Hz, AdB allowable equals 60

$\therefore a = .01 \text{ m/sec}^2$ @ 0.5 Hz |F.S. = 1.57|

ii @ 1.0 Hz, AdB allowable equals 60

$\therefore$ @ $= .01 \text{ m/sec}^2$ @ 0.5 Hz |F.S. = .787|



MAXIMUM STRUCTUREBORNE NOISE IN HULL STRUCTURES NEAR DRSS

APPENDIX G

APPENDIX G

CABLE ANALYSIS

APPENDIX G

CABLE ANALYSIS

1. Allowable Stress = $3000\#_f/\text{Area}_{\text{Cross Section}}$

   $= 3000/.3316 \text{ in.}^2 = 9047\#_f/\text{in.}^2$

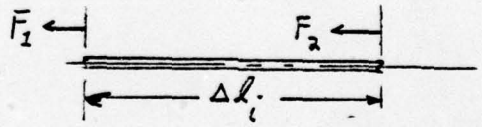
2. Per DRSS Cable Test, the Elastic Modulus measured equals, (Refer to Figures 1 and 2)

   $E = \sigma / \varepsilon = 17{,}882\#_f/\text{in.}^2$

   - Measured elongation @ $115\#_f$ load, 11.88 in. between split clamps equals .2003 inches
   - Assuming that a transfer mechanism imposes a maximum $600\#_f$/linear ft differential

     (= .0169"/in. x 6 = .1014"/in. allowable)

   - Note that the over-boarded cable elongation equals function F1-F2 per unit length



@ 1#/ft = .051 elongation over 3000' cable scope

Normal uniform loading equals .6 → 1.2#/ft (Drag)

Estimated outer fiber elongation for 12" P.D. sheave =

$$\left(\frac{dr}{ds} \times 100\%, = \frac{.65"}{12"} \times 100, = 5.4\%\right)$$

while linear % elongation @ $300\#_f$/linear ft loading =

$$\frac{.0507"/\text{in.} \times 11.88}{11.88} = 4.9\%$$

3. Buckling test results are shown in Figure 3.

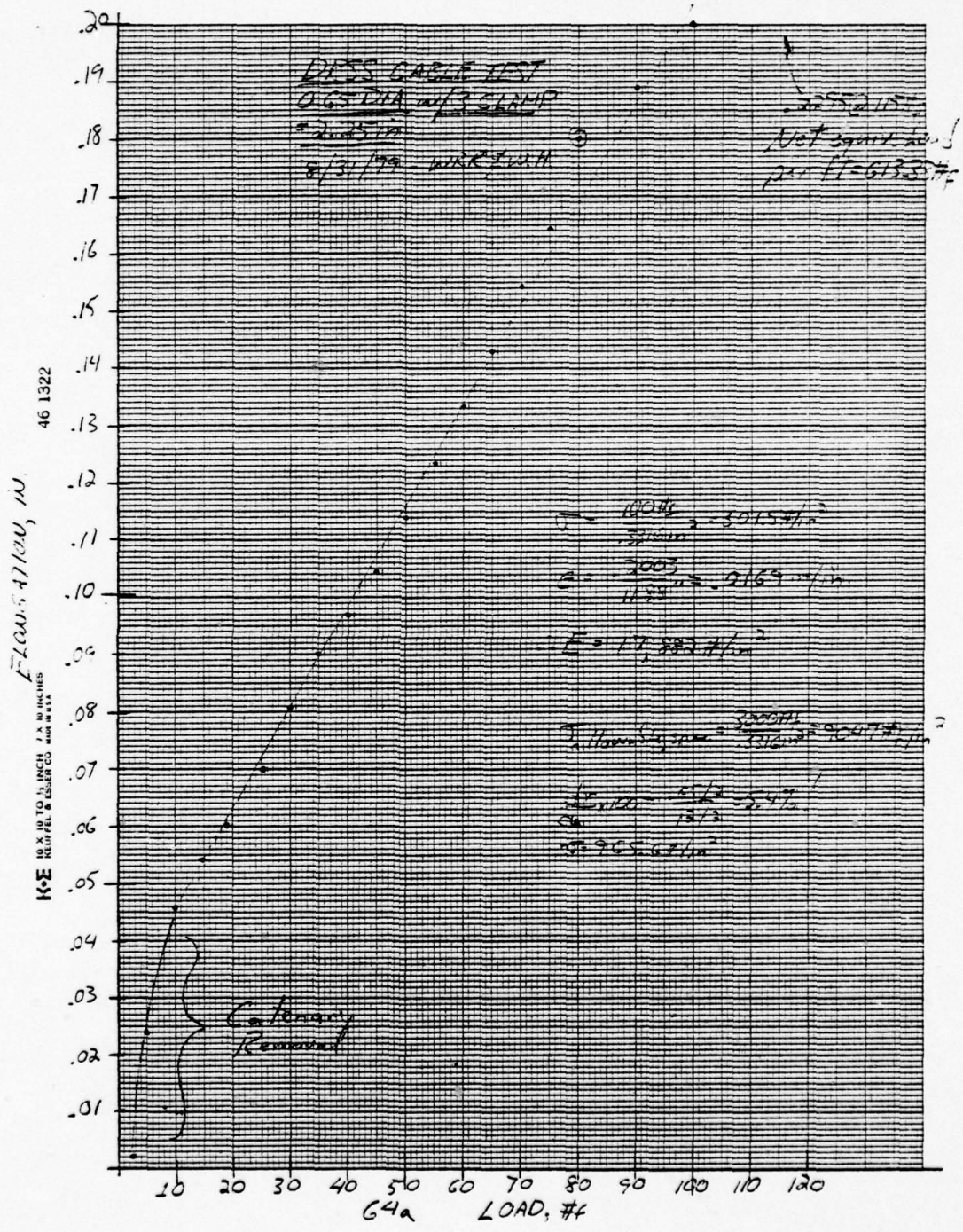


Figure 1

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

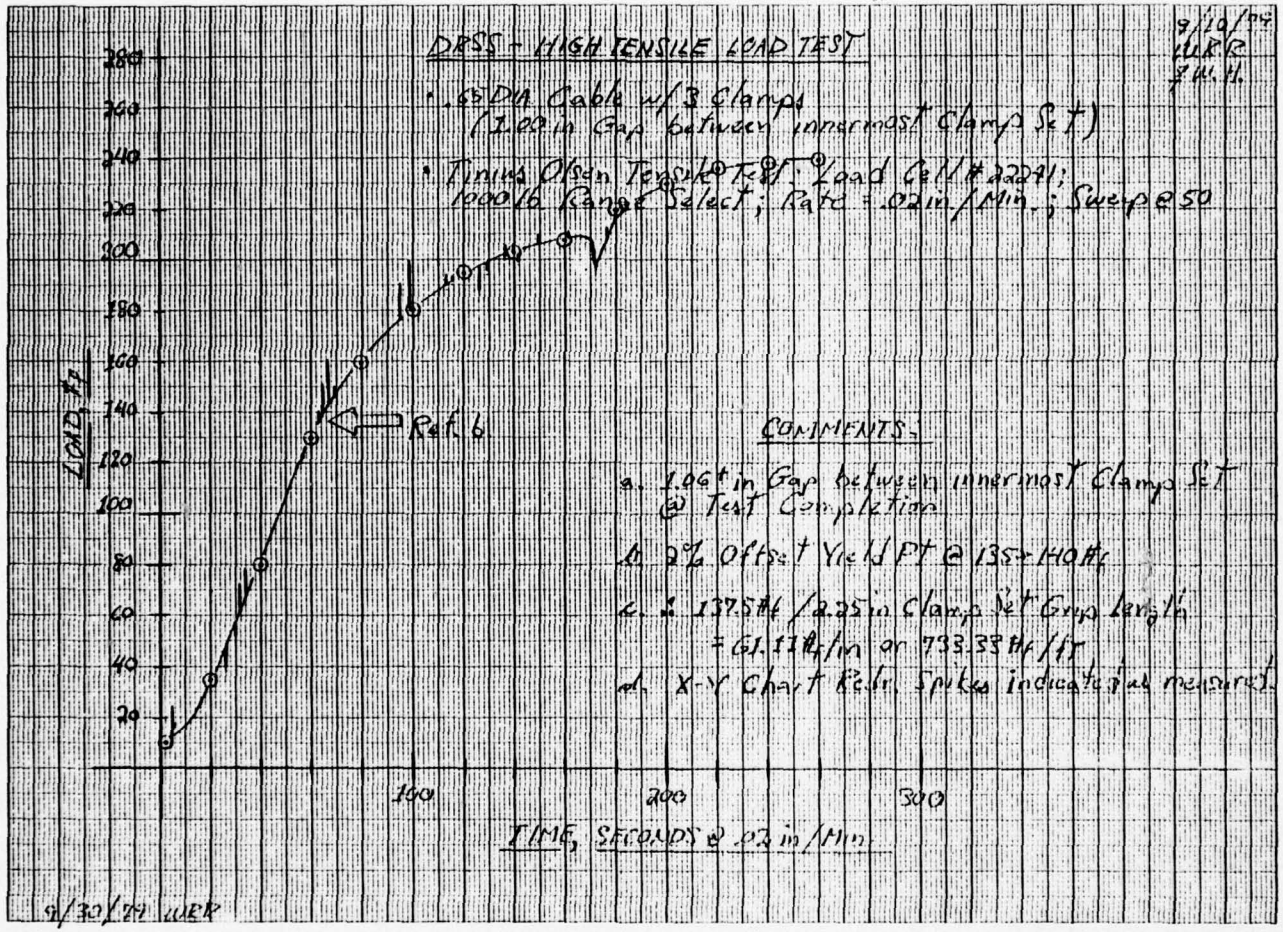
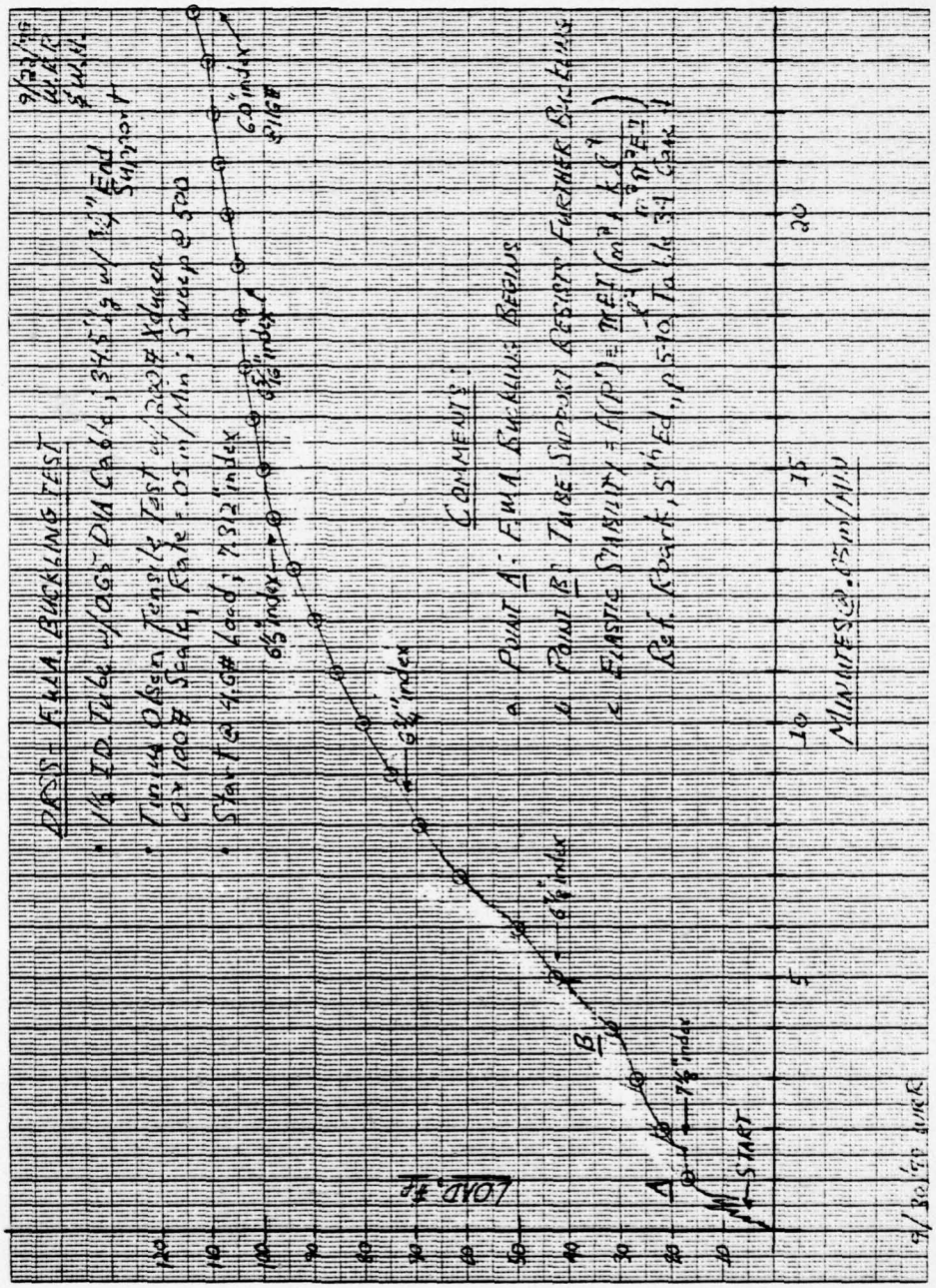


Figure 2

10 Millimeters to the Centimeter
FOLD
FOLD
BEST AVAILABLE COPY
THIS PAGE IS BEST QUALITY PRACTICABLE FROM COPY FURNISHED TO DDC

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC



10 Millimeters to the Centimeter

Figure 3

Test Plan: DRSS Cable Test

1. • Install 18.00 $\pm$ 1/16th inch length 0.65 Dia Cable into Split Clamp assys.
   • Assure that 1/2 inch excess cable projects from the end of the last split clamp.
   • Assure that the band clamps are tightened such that < 1/16th inch gap exists between clamp halves. Tighten as much as possible by hand.
2. • Install completed Testing Fixture into Tensile Tester.
   • Predicted load range will be from

     $18.75\#_{f\ min} \longrightarrow 75\#_{f(desired)} \longrightarrow 187.5\#_{f\ max\ theoretical}$.

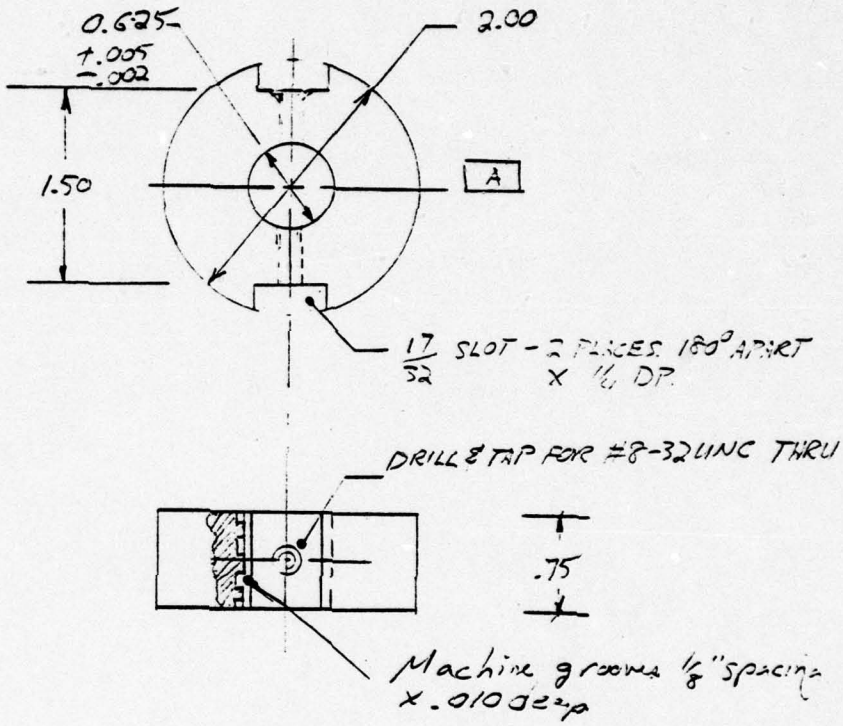
   • Rate of load application should be as slow as possible in order to observe failure mode(s).
3. • If time permits, repeat above with 2 Split Clamps/end; then 1 Split Clamp/end. A new length of cable must be used for each repeat test.

TINIUS OLSEN TESTING MACH. TEST RESULTS

Reverse Load Cell 722241
Dial Indicator - Mitutoyo CIC #03-1241
Range - 200#
Rate .05"/min, 3 clamps: .75" thk

	Load	Elongation	
1	2.7	.002	
2	5.0	.0245	Catenary Removal
3	10.1	.046	
4	14.7	.054	
5	19.0	.0655	
6	25.0	.0708	
7	30.0	.081	
8	35.0	.0903	
9	40.0	.097	
10	45.0	.1045	$\simeq$4 sec for relaxation of $4\#_f$
11	50.0	.1135	
12	55.0	.1235	
13	60.0	.1335	
14	65.0	.1430	
15	70.0	.1545	
16	75.0	.1645	adjusted rate to 0.02 in./min
17	80.0	.1795	(5 sec/.001 creep measurement)
18	90.0	.1885	
19	100.0	.2002	
20	115.0	.2295	

Refer to Figure 1, for data plot.



NOTES:

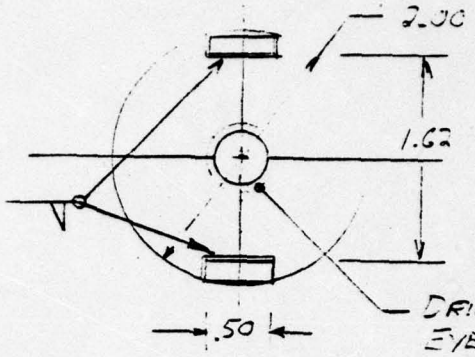
1. MAT'L - ALUM OR STEEL BAR
2. AFTER MACHINING, CUT DISC IN HALF ALONG [A]
3. Nº REQD = 6

SH 1 of 2 TEST CLAMP FIXTURE - F.W.A. SHEAR TEST
(79108.0203)

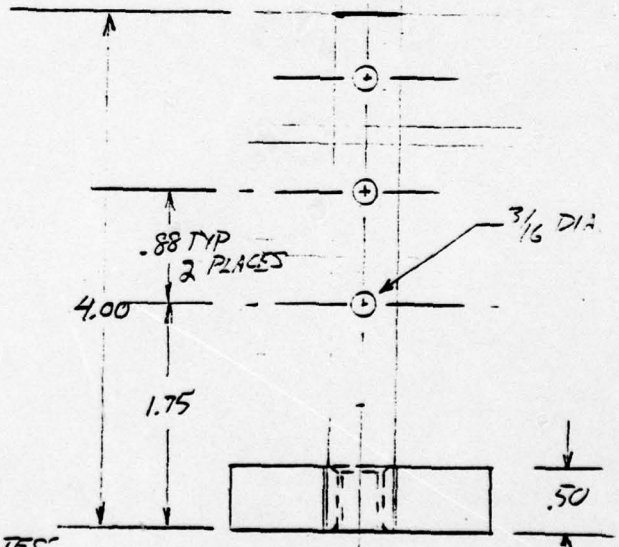
8/22/79
WRR.

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

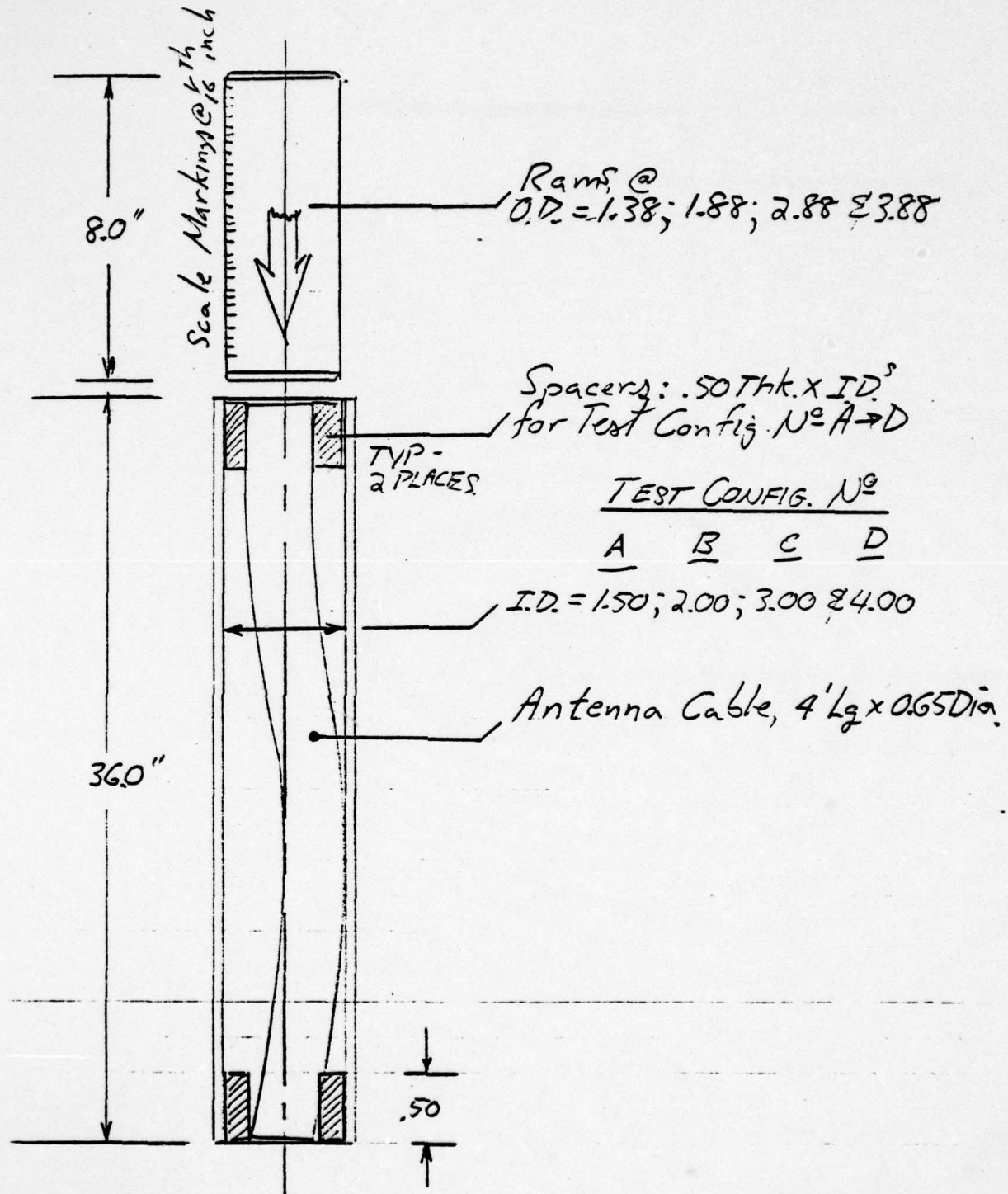


DRILL & TAP FOR INVERTED EYEBOLT MOUNTINGS. SIZE TO BE SELECTED AS APPROPRIATE FOR STAT LOAD RATINGS.



NOTES:
1. MAT'L - STEEL FLAT 1/8 x 1/2 x 4" Lg --4 PIECES
& STL RD 2"OD x 2 1/2 THK - 2 PIECES

SH 2 of 2 TEST CLAMP FIXTURE TIE BAR ASSY - FWA SHEAR TE 69



F.W.A. BUCKLING TEST
79108.0203

8/27/79
WRR

Comparison of Test Results, Figure 1 and 2 to Analogous Materials for Cable

PCVs Sp. 6r = 1.5!

3000 - 5000 psi tensile

4.5 - 65% elongation

350 - 6,000,000 psi modulus

9000 - 22,000 psi compressive

Polyurethanes Sp. 6r = 1.05!

2000 - 8400 psi tensile

100 - 600% elongation

100 - 350,000 psi modulus

20,000 psi compressive

Polypropylenes Sp. 6r = .90!

2900 - 4500 psi tensile

3 - 20% elongation

40 - 80,000 psi modulus

3700 - 8000 psi compressive

Polyethylenes Sp. 6r = .95!

1600 - 4600 psi tensile

10% - 49% elongation

50 - 500,000 psi modulus

2000 - 5500 psi compressive

& Low Density Sp. 6r = .91!

600 - 2300 psi tensile

90 - 800% elongation

14 - 38,000 psi modulus

2700 psi compressive

APPENDIX H

APPENDIX H

BUOYANT CABLE ASSEMBLY DEPTH VS SPEED

COMPUTER ANALYSIS

APPENDIX H

BUOYANT CABLE ASSEMBLY DEPTH VS SPEED COMPUTER ANALYSIS

Objective: Determination of submarine speed vs Cable/Antenna Length vs Operation Depth Computer Prediction

Purpose: (1) Ascertain 'best guess' of optimum operational Profile

(2) Confirm dynamic loading requirements

Expected Results: Narrowing of the operational envelope performance reqts/goals --in order to optimize DRSS system characterization

Review of the specifications yields the following data:

MIL-C-28751 (EC), 27 July 1970 para. 3.2.1.1

- Sp. Gr. $\leq$ .85 @ hydrostatic pressure of 600 psig @ room temperature, in fresh water after two hours immersion. (Approved test method contained in *USNUSL Tech. Memorandum #220-74-62.*)
- RG-373/U Cable OD equals .650 $\pm$ .025 inch
- RG-373/U Cable Str = 2000# minimum

MIL-C-28726 (EC), 9 Jan 1970 para. 4.6.4

- Sp. Gr. $\leq$ .92 (ditto above)
- RG-384/U Cable OD equals .650 $\pm$ .025 inch
- RG-384/U Cable Str. = 2000# minimum

SPEC. NUSC-C-342/4141-279 20 July 77

- Sp. Gr. = 0.73 @ 450 psig (Type I, NUSC-C-279/1-10)
- Cable OD equals .650 $\pm$ .020 inch
- Cable Str. = 400# minimum @ break
- Sp. Gr. = 0.79 @ 450 psig (Type II, NUSC-C-279/2-10)
- Cable OD equals .650 $\pm$ .020 inch
- Cable Str. = 3000# minimum @ break

GOULD

GOULD INC., CHESAPEAKE INSTRUMENT DIVISION

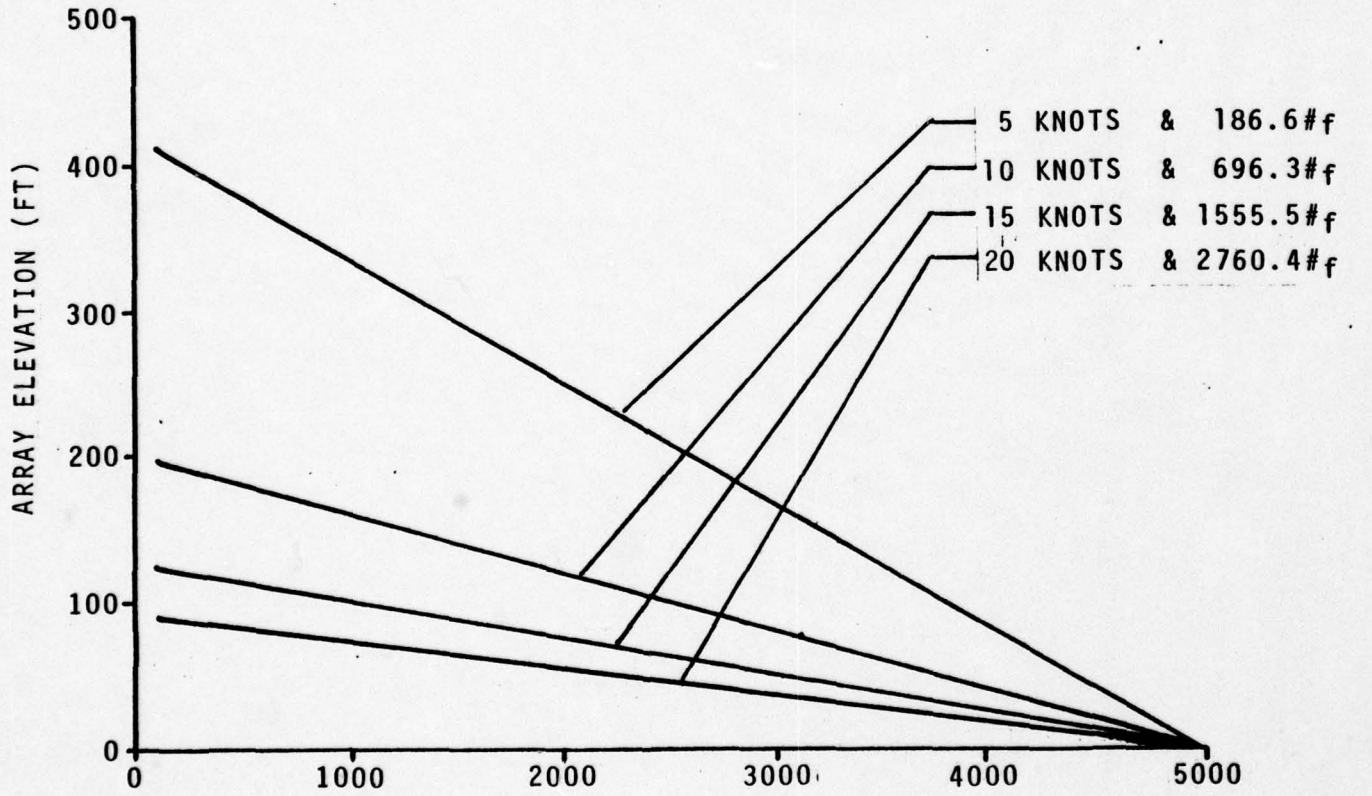
BCA DEPTH VS SPEED

CABLE SCOPE =500ft.

CABLE DRAMETER = 0.650in.

CABLE SPECIFIC GRAVITY = 0.795 .(TENSIONS MARGINALLY, EQUAL TO THOSE FOR CABLE PROGRAM)

SEAWATER SPECIFIC GRAVITY =1.0247 .(ELEVATIONS 55.33% OF THOSE FOR "CABLE" PROGRAM)



4249

- Sp. Gr. = 0.80 @ psig (Type II, NUSC-C-279/2-11)
- Cable OD equals .650 $\pm$ .020 inch
- Cable Str. = 3000# minimum @ break
- Sp. Gr. = 0.82 @ 450 psig (Type III, NUSC-C-279/3-10)
- Cable OD equals .650 $\pm$ .020 inch
- Cable Str. = 1900# minimum @ break

As only Type II, NUSC-C-279/2-10 and 2-11 current meet the minimum strength requirements, we should select the Sp. Gr. = 0.795 as the figure-of-merit and cable dia = .650 $\pm$ .020 inch.

Analysis should be run @ 5, 10, 15, and 20 knots SOA for 3000 and 5000'. Outboard drag forces should be provided for each case. It will not be necessary at this time to develop the profile, but only depth.

Tabulation of Information for DIALCOM

Access to SHAPE 6

1. Tel. No. 8-589-4816

   Please sign on

   ? HALF, DELAY

   ? ID 310 VBX(CTRL)

   ? IOEWW Project No

   ? LIST SHAPE 6

   ? EDIT DRSS - - - - - - - - - - - Never hit Return during Edit!

   P - Prints line where pointer is at

   To move Pointer

   P^{X} – Points to Line #X

   N - Points to next line

   T - Points to Top line

   L/XXX/ - Will find character string XXX

   C/Old String/New String

   Q - Quit

   ? Fortran SHAPE 6 SH 6

   ? LLOAD SH6

```
LIST SHAPE6

   10 COMMON/CAB/D,CD,VSQ,PI,N
   20 DIMENSION THETA(4),SI(100),DI(100),CDI(100),STEP(100)
   30 DIMENSION DIT(100),CDIT(100),STEPT(100)
   40 EXTERNAL F
   50 CALL DEFINE(2,'TREES,')
51 M1=0
52 K=0
   70 N=4
   80 77 PI=3.14159
   90 WRITE(9,10)
  100 10 FORMAT(///,1H1,1X,'=INPUT DATA: ')
  110 21 FORMAT(3F9.3)
  120 READ(1,5) T
  130 5 FORMAT(F10.3)
  140 IF(T.LT.1.0) T=1.0
  150 WRITE(9,7) T
  155 WRITE(9,14)
  156 14 FORMAT(3X,'SPECIFIC GRAVITY CONVERSION FACTOR=')
  157 READ(9,17) CHANGE
  158 17 FORMAT(F10.6)
  160 7 FORMAT(///,5X,'INITIAL TENSION=',F7.2,1X,'LBS')
  170 WRITE(9,9)
  180 9 FORMAT(//,6X,'S',8X,'DIAM',6X,'SPECIFIC',
  190 +2X,'INTERMEDIATE')
  200 WRITE(9,12)
  210 12 FORMAT(3P,'(FEET)',4X,'(INCHES)',4X,'GRAVITY',3X,
  220 +'STEP SIZE',/)
  230 I=1
  240 15 READ(1,6) SI(I),DIT(I),CDIT(I),STEPT(I)
  250 6 FORMAT(F7.2,1X,F6.4,1X,F6.4,1X,F6.3)
  260 16 FORMAT(4F10.4)
  270 D=DIT(I)
  280 I=I+1
  290 IF(D.GT.0.) GO TO 15
  300 II=I-1
  320 DO 40 IK=1,II
  330 CDIT(IK)=CDIT(IK)+CHANGE
  370 WRITE(9,16) SI(IK),DIT(IK),CDIT(IK),STEPT(IK)
  380 40 CONTINUE
  440 18 FORMAT(I2)
  450 19 READ(1,5) V
  460 IF(V.EQ.0.) GO TO 77
  470 IF(V.LT.0.) GO TO 20
  480 WRITE(9,4) V
  490 4 FORMAT(///,1H1,1X,'VELOCITY=',F6.2,1X,'KNOTS')
  500 VSQ=(V*1.688)**2.
  510 WRITE(9,1)
  520 1 FORMAT(///,7X,'S (FT)',5X,'TENSION (LBS)',3X,
  530 +'THETA (DEGREES)',3X,'X (FT)',7X,'Y (FT)')
  540 THETA(1)=T
  550 THETA(2)=0.0
  560 THETA(3)=0.0
  570 THETA(4)=0.0
  580 S=0.0
  600 CONTINUE
  610 I=1
  620 11 IF(DIT(I).EQ.0.) GO TO 19
  630 S=SI(I)
  640 D=DIT(I)/12.
  645 NI=I+1
```


THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
      DD=DIT(N1)/12.
      CD=CDIT(I)
      SMAX=SI(I+1)-0.0001
   13 H=STEPT(I)
      HMAX=SI(I+1)-S
      IF(HMAX.LT.H) H=HMAX
      CALL DIFSYS(F,S,THETA,H)
      THET=THETA(2)*(180.0/PI)
      WRITE(9,2) S,THETA(1),THET,THETA(3),THETA(4)
      WRITE(2,21) DD,THETA(3),THETA(4)
    2 FORMAT(4(F13.3,2X),F9.3)
      IF(S.LT.SMAX) GO TO 13
      I=I+1
      GO TO 11
   20 DD=-1
      WRITE(2,28) DD
   28 FORMAT(2X,F9.3)
      STOP
      END
      SUBROUTINE DIFSYS(F,X,Y,H)
      COMMON/CAB/D,CD,VSQ,PI,N
      DIMENSION Y(N)
      DIMENSION DY0(10),YT(12,15),YP(10),YA(10),DY(10),
     +T1(10),T2(10),T3(10),T4(10)
      DATA EPS/1.0E-7/
      DATA MAXITR/10/
      ERR=1.0E-7
      CALL F(Y,DY0,M1)
      DO 100 I=1,N
  100 YT(1,I)=0.0
      XF=X+H
      M=1
      ITR=0
  150 XX=X
      HH=.5*H
      DO 200 I=1,N
      YP(I)=Y(I)
  200 YA(I)=Y(I)+HH*DY0(I)
      CONTINUE
      DO 300 J=1,M
      XX=XX+HH
      CALL F(YA,DY,M1)
      DO 300 I=1,N
      TEMP=YP(I)
      YP(I)=YA(I)
      YA(I)=TEMP+H*DY(I)
  300 CONTINUE
      H=HH
      M=2*M+1
      IF(ITR.NE.0) GO TO 400
      ITR=1
      DO 350 I=1,N
      T1(I)=YA(I)
      T2(I)=0.
  350 YT(2,I)=YA(I)
      GO TO 150
  400 CONTINUE
      DO 450 I=1,N
      T4(I)=YT(2,I)
  450 CONTINUE
      II=ITR
      IF(II.GT.5) II=5
      ERRA=0.0
      ERRB=0.0
```

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
1270 ERRC=0.0
1280 YNORM=0.0
1290 DO 500 I=1,N
1300 POWER=1.0
1310 DO 480 J=1,II
1320 POWER=4.8*POWER
1330 TB=YA(I)-YT(J,I)
1340 IF(J.GE.2) YT(J,I)=TX
1350 TX=YA(I)
1360 TC=TX-YT(J+1,I)
1370 IF(TB.EQ.0.) GO TO 480
1380 TB=1.000-TC/TB
1390 YA(I)=YA(I)+TC/(POWER*TB-1.0)
1400 480 CONTINUE
1410 YT(II+1,I)=TX
1420 YT(II+2,I)=YA(I)
1430 T3(I)=T2(I)
1440 T2(I)=T1(I)
1450 T1(I)=YA(I)
1460 TEMP=DABS(YA(I))
1470 IF(YNORM.LT.TEMP) YNORM=TEMP
1480 TB=DABS(YT(2,I)-T4(I))
1490 IF(ERRA.LT.TB) ERRA=TB
1500 TB=DABS(T1(I)-T2(I))
1510 IF(ERRB.LT.TB) ERRB=TB
1520 TB=DABS(T2(I)-T3(I))
1530 IF(ERRC.LT.TB) ERRC=TB
1540 500 CONTINUE
1550 ITR=ITR+1
1560 IF(ITR.LT.3) GO TO 150
1570 IF(ERRA.LT.ERRB) GO TO 600
1580 IF(ERRC.NE.0.) ERRB=ERRB*ERRB/ERRC
1590 IF(YNORM.NE.0.0) ERRB=ERRB/YNORM
1600 IF(ERRB.LT.ERR) GO TO 550
1610 540 IF(ITR.LT.MAXITR) GO TO 150
1620 WRITE(9,900) ERRB
1630 550 ERR=ERRB
1640 IF(ERR.LT.EPS) ERR=EPS
1650 X=XF
1660 I=6
1670 IF(ITR.LT.6) I=1+ITR
1680 DO 570 I=1,N
1690 570 Y(I)=YA(I)
1700 RETURN
1710 600 ERRB=0.25*ERRA
1720 IF(YNORM.NE.0.0) ERRB=ERRB/YNORM
1730 IF(ERRB.GT.ERR) GO TO 540
1740 DO 650 I=1,N
1750 650 YA(I)=YT(2,I)
1760 GO TO 550
1770 800 WRITE(9,901)
1780 RETURN
1790 900 FORMAT('CAUTION-ERROR IN DIFSYS',/,
1800 +'SOLUTION FOUND HAS RELATIVE ERROR=',E11.2)
1810 901 FORMAT('ERROR IN DIFSYS,SYSTEM TOO LARGE',/)
1820 END
1830 SUBROUTINE F(THETA,FSTHET)
1840 COMMON/CAB/D,CD,VSQ,PI
1850 DIMENSION THETA(4),FSTHET(4)
1860 DATA SPGR/1.94/,G/32.1756/
1870 A=PI*D*D/4.
1880 T=THETA(2)
```

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
1890  STH=SIN(T)
 1900 CTH=COS(T)
1902  IF(M1.EQ.1) GO TO 10
1903  WRITE(9,221)
1904  221 FORMAT(3X,'YOUR SP. GR. FOR NEUT. BOUY. IN SALT WATER')
1905  READ(9,222) WD
1906  222 FORMAT(F10.6)
1907  M1=1
1908  10 CONTINUE
 1910 GC=G*A*SPGR*(CD-WD)
 1920 DC=.5*VSQ*D*WD*SPGR
 1930 TAU=THETA(1)
 1940 SGN=1.0
 1950 IF(T.LT.0.0) SGN=-1.0
 1951 DRAG=.009
 1960 FSTHET(1)=GC*STH+DC*DRAG*CTH
 1970 FSTHET(2)=(GC*CTH-DC*(DRAG*STH+1.1*STH*SSTH*SGN))/TAU
1980  FSTHET(3)=CTH
 1990 FSTHET(4)=STH
 2000 RETURN
 2010 END
```

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
1 =INPUT DATA: DEFINE FILE(S)
1=DRSS


    INITIAL TENSION=   1.00 LBS
  SPECIFIC GRAVITY CONVERSION FACTOR=! 1.00


   S          DIAM        SPECIFIC   INTERMEDIATE
(FEET)      (INCHES)      GRAVITY    STEP SIZE

     0.0000     0.6500     0.7950     4.0000
  5000.0000     0.0000     0.0000     0.0000


1 VELOCITY=  3.00 KNOTS


      S (FT)      TENSION (LBS)   THETA (DEGREES)   X (FT)        Y (FT)
 YOUR SP. GR. FOR NEUT. BOUY. IN SALT WATER! 1.0247

     104.000          2.755          -8.204        102.983      -14.389
     208.000          4.525          -8.204        205.918      -29.231
     312.000          6.294          -8.204        308.854      -44.072
     416.000          8.063          -8.204        411.791      -58.913
     520.000          9.833          -8.204        514.728      -73.755
     624.000         11.602          -8.204        617.661      -88.596
     728.000         13.372          -8.204        720.595     -103.438
     832.000         15.141          -8.204        823.529     -118.280
     936.000         16.910          -8.204        926.462     -133.121
    1040.000         18.680          -8.204       1029.396     -147.962
    1144.000         20.449          -8.204       1132.329     -162.803
    1248.000         22.219          -8.204       1235.263     -177.643
    1352.000         23.988          -8.204       1338.197     -192.484
    1456.000         25.758          -8.204       1441.130     -207.325
    1560.000         27.527          -8.204       1544.064     -222.166
    1664.000         29.296          -8.204       1646.997     -237.007
    1768.000         31.066          -8.204       1749.931     -251.847
    1872.000         32.835          -8.204       1852.865     -266.688
    1976.000         34.605          -8.204       1955.798     -281.529
    2080.000         36.374          -8.204       2058.732     -296.370
    2184.000         38.143          -8.204       2161.666     -311.211
    2288.000         39.913          -8.204       2264.599     -326.052
    2392.000         41.682          -8.204       2367.533     -340.892
    2600.000         45.221          -8.204       2573.400     -370.574
    2704.000         46.990          -8.204       2676.333     -385.415
    2808.000         48.760          -8.204       2779.267     -400.256
    2912.000         50.529          -8.204       2882.201     -415.096
    3016.000         52.299          -8.204       2985.134     -429.937
    3120.000         54.068          -8.204       3088.068     -444.778
    3224.000         55.837          -8.204       3191.001     -459.619
    3328.000         57.607          -8.204       3293.935     -474.460
    3432.000         59.376          -8.204       3396.869     -489.301
    3536.000         61.146          -8.204       3499.802     -504.141
    3640.000         62.915          -8.204       3602.736     -518.982
    3744.000         64.685          -8.204       3705.669     -533.823
    3848.000         66.454          -8.204       3808.603     -548.664
    3952.000         68.223          -8.204       3911.536     -563.505
    4368.000         75.301          -8.204       4323.271     -622.868
    4472.000         77.070          -8.204       4426.205     -637.709
    4576.000         78.840          -8.204       4529.139     -652.550
    4680.000         80.609          -8.204       4632.072     -667.391
    4784.000         82.379          -8.204       4735.006     -682.231
    4888.000         84.148          -8.204       4837.939     -697.072
    4992.000         85.917          -8.204       4940.873     -711.913ILLEGAL ENT
RY TO JOBMN AT 000002

 JOB ERROR
```


THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
?LLOAD SH6


1 =INPUT DATA: DEFINE FILE(S)
1=DRSS


     INITIAL TENSION=   1.00 LBS
   SPECIFIC GRAVITY CONVERSION FACTOR=! 1.00


   S          DIAM        SPECIFIC   INTERMEDIATE
(FEET)      (INCHES)      GRAVITY    STEP SIZE

    0.0000     0.6500     0.7950     4.0000
 5000.0000     0.0000     0.0000     0.0000


1 VELOCITY=  5.00 KNOTS


      S (FT)       TENSION (LBS)    THETA (DEGREES)    X (FT)         Y (FT)
 YOUR SP. GR. FOR NEUT. BOUY. IN SALT WATER! 1.0247

     104.000          4.362          -4.838          103.639        -8.610
     208.000          8.729          -4.838          207.268       -17.381
     312.000         12.595          -4.838          310.897       -26.153
     416.000         16.462          -4.838          414.526       -34.925
     520.000         20.329          -4.838          518.155       -43.696
     624.000         24.195          -4.838          621.786       -52.468
     728.000         28.062          -4.838          725.418       -61.240
     832.000         31.929          -4.838          829.050       -70.011
     936.000         35.796          -4.838          932.682       -78.783
    1040.000         39.663          -4.838         1036.314       -87.555
    1144.000         43.530          -4.838         1139.946       -96.326
    1248.000         47.396          -4.838         1243.577      -105.098
    1352.000         51.263          -4.838         1347.209      -113.870
    1456.000         55.130          -4.838         1450.841      -122.641
    1560.000         58.997          -4.838         1554.473      -131.413
    1664.000         62.864          -4.838         1658.105      -140.186
    1768.000         66.731          -4.838         1761.737      -148.958
    1872.000         70.597          -4.838         1865.368      -157.731
    1976.000         74.464          -4.838         1969.000      -166.503
    2080.000         78.330          -4.838         2072.629      -175.276
    2184.000         82.197          -4.838         2176.248      -184.048
    2288.000         86.063          -4.838         2279.867      -192.820
    2392.000         89.930          -4.838         2383.486      -201.593
    2496.000         93.796          -4.838         2487.105      -210.365
    2600.000         97.663          -4.838         2590.725      -219.138
    2704.000        101.529          -4.838         2694.344      -227.910
    2808.000        105.396          -4.838         2797.963      -236.683
    2912.000        109.262          -4.838         2901.582      -245.455
    3016.000        113.129          -4.838         3005.201      -254.228
    3120.000        116.995          -4.838         3108.820      -263.000
    3224.000        120.862          -4.838         3212.439      -271.773
    3328.000        124.728          -4.838         3316.059      -280.545
    3432.000        128.595          -4.838         3419.678      -289.318
    3536.000        132.462          -4.838         3523.297      -298.090
    3640.000        136.330          -4.838         3626.916      -306.862
    3744.000        140.197          -4.838         3730.535      -315.635
    3848.000        144.064          -4.838         3834.154      -324.407
    3952.000        147.932          -4.838         3937.773      -333.180
    4056.000        151.799          -4.838         4041.393      -341.952
    4160.000        155.666          -4.838         4145.023      -350.725
    4264.000        159.534          -4.838         4248.668      -359.497
    4368.000        163.401          -4.838         4352.313      -368.270
    4472.000        167.268          -4.838         4455.957      -377.042
    4576.000        171.136          -4.838         4559.602      -385.815
    4680.000        175.003          -4.838         4663.246      -394.587
    4784.000        178.870          -4.838         4766.891      -403.360
    4888.000        182.737          -4.838         4870.535      -412.132
    4992.000        186.605          -4.838         4974.180      -420.904ILLEGAL ENT
RY TO JOBMN AT 000002

 JOB ERROR
?
```


THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
1 =INPUT DATA: DEFINE FILE(S)
1=DRSS


     INITIAL TENSION=    1.00 LBS
   SPECIFIC GRAVITY CONVERSION FACTOR=! 1.00


    S          DIAM        SPECIFIC   INTERMEDIATE
 (FEET)      (INCHES)      GRAVITY    STEP SIZE

     0.0000     0.6500      0.7950     4.0000
  5000.0000     0.0000      0.0000     0.0000


1 VELOCITY=  7.50 KNOTS

        S (FT)      TENSION (LBS)    THETA (DEGREES)    X (FT)        Y (FT)
   YOUR SP. GR. FOR NEUT. BOUY. IN SALT WATER! 1.0247

      104.000          9.252          -3.153          103.846       -5.649
      208.000         17.505          -3.153          207.688      -11.369
      312.000         25.759          -3.153          311.531      -17.090
      416.000         34.013          -3.153          415.372      -22.810
      520.000         42.266          -3.153          519.213      -28.531
      624.000         50.520          -3.153          623.054      -34.251
      728.000         58.773          -3.153          726.896      -39.972
      832.000         67.027          -3.153          830.737      -45.692
      936.000         75.280          -3.153          934.578      -51.412
     1040.000         83.534          -3.153         1038.421      -57.133
     1144.000         91.787          -3.153         1142.268      -62.853
     1248.000        100.041          -3.153         1246.116      -68.574
     1352.000        108.294          -3.153         1349.964      -74.295
     1456.000        116.548          -3.153         1453.811      -80.016
     1560.000        124.802          -3.153         1557.659      -85.736
     1664.000        133.055          -3.153         1661.507      -91.457
     1768.000        141.309          -3.153         1765.354      -97.178
     1872.000        149.562          -3.153         1869.202     -102.899
     1976.000        157.816          -3.153         1973.050     -108.619
     2080.000        166.069          -3.153         2076.898     -114.340
     2184.000        174.323          -3.153         2180.745     -120.061
     2288.000        182.576          -3.153         2284.593     -125.781
     2392.000        190.830          -3.153         2388.441     -131.502
     2496.000        199.083          -3.153         2492.288     -137.224
     2600.000        207.337          -3.153         2596.135     -142.945
     2704.000        215.591          -3.153         2699.983     -148.665
     2808.000        223.844          -3.153         2803.831     -154.386
     2912.000        232.098          -3.153         2907.678     -160.107
     3016.000        240.351          -3.153         3011.526     -165.828
     3120.000        248.605          -3.153         3115.374     -171.549
     3224.000        256.858          -3.153         3219.221     -177.270
     3328.000        265.114          -3.153         3323.069     -182.990
     3432.000        273.369          -3.153         3426.917     -188.711
     3536.000        281.624          -3.153         3530.764     -194.432
     3640.000        289.879          -3.153         3634.612     -200.153
     3744.000        298.134          -3.153         3738.460     -205.875
     4056.000        322.899          -3.153         4050.002     -223.036
     4160.000        331.155          -3.153         4153.850     -228.757
     4264.000        339.410          -3.153         4257.697     -234.478
     4368.000        347.665          -3.153         4361.545     -240.199
     4472.000        355.920          -3.153         4465.393     -245.920
     4576.000        364.175          -3.153         4569.240     -251.640
     4680.000        372.430          -3.153         4673.088     -257.361
     4784.000        380.685          -3.153         4776.936     -263.080
     4888.000        388.940          -3.153         4880.783     -268.799
     4992.000        397.196          -3.153         4984.631     -274.518ILLEGAL ENT
RY TO JOBMN AT 000002

 JOB ERROR
```


THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
1 =INPUT DATA: DEFINE FILE(S)
1=DRSS


     INITIAL TENSION=   1.00 LBS
   SPECIFIC GRAVITY CONVERSION FACTOR=: 1.00


   S         DIAM       SPECIFIC   INTERMEDIATE
(FEET)     (INCHES)     GRAVITY    STEP SIZE

    0.0000     0.6500     0.7950     4.0000
 5000.0000     0.0000     0.0000     0.0000


1 VELOCITY= 10.00 KNOTS


      S (FT)      TENSION (LBS)    THETA (DEGREES)    X (FT)        Y (FT)
   YOUR SP. GR. FOR NEUT. BOUY. IN SALT WATER: 1.0247

     104.000         15.485          -2.311         103.917      -4.154
     208.000         29.970          -2.311         207.832      -8.348
     312.000         44.456          -2.311         311.747     -12.543
     416.000         58.942          -2.311         415.662     -16.737
     520.000         73.428          -2.311         519.576     -20.931
     624.000         87.914          -2.311         623.494     -25.125
     728.000        102.400          -2.311         727.411     -29.319
     832.000        116.886          -2.311         831.328     -33.514
     936.000        131.372          -2.311         935.246     -37.708
    1040.000        145.858          -2.311        1039.163     -41.902
    1144.000        160.343          -2.311        Q143.074     -46.096
    1248.000        174.828          -2.311        1246.985     -50.290
    1352.000        189.314          -2.311        1350.896     -54.485
    1456.000        203.799          -2.311        1454.807     -58.679
    1560.000        218.284          -2.311        1558.718     -62.873
    1664.000        232.770          -2.311        1662.629     -67.067
    1768.000        247.255          -2.311        1766.541     -71.262
    1872.000        261.740          -2.311        1870.452     -75.456
    1976.000        276.226          -2.311        1974.363     -79.650
    2080.000        290.711          -2.311        2078.278     -83.844
    2184.000        305.197          -2.311        2182.202     -88.038
    2288.000        319.682          -2.311        2286.125     -92.233
    2392.000        334.167          -2.311        2390.049     -96.427
    2496.000        348.653          -2.311        2493.973    -100.621
    2600.000        363.138          -2.311        2597.897    -104.815
    2704.000        377.623          -2.311        2701.821    -109.009
    2808.000        392.109          -2.311        2805.745    -113.204
    2912.000        406.594          -2.311        2909.668    -117.398
    3016.000        421.079          -2.311        3013.592    -121.592
    3120.000        435.565          -2.311        3117.516    -125.786
    3224.000        450.050          -2.311        3221.440    -129.980
    3328.000        464.535          -2.311        3325.364    -134.175
    3432.000        479.021          -2.311        3429.288    -138.369
    3536.000        493.506          -2.311        3533.211    -142.563
    3640.000        507.991          -2.311        3637.135    -146.757
    3744.000        522.477          -2.311        3741.059    -150.952
    3848.000        536.962          -2.311        3844.983    -155.146
    3952.000        551.448          -2.311        3948.907    -159.340
    4056.000        565.933          -2.311        4052.831    -163.534
    4160.000        580.418          -2.311        4156.739    -167.728
    4264.000        594.904          -2.311        4260.638    -171.923
    4368.000        609.389          -2.311        4364.536    -176.117
    4472.000        623.874          -2.311        4468.435    -180.311
    4576.000        638.360          -2.311        4572.333    -184.505
    4680.000        652.845          -2.311        4676.231    -188.699
    4784.000        667.330          -2.311        4780.130    -192.894
    4888.000        681.816          -2.311        4884.028    -197.088
    4992.000        696.301          -2.311        4987.927    -201.282ILLEGAL ENT
RY TO JOBMN AT 000002

 JOB ERROR
?EDIT DRSS
```


THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
1 =INPUT DATA: DEFINE FILE(S)
1=DRSS


     INITIAL TENSION=   1.00 LBS
   SPECIFIC GRAVITY CONVERSION FACTOR=! 1.00


   S         DIAM       SPECIFIC   INTERMEDIATE
(FEET)     (INCHES)     GRAVITY    STEP SIZE

    0.0000     0.6500     0.7950     4.0000
 5000.0000     0.0000     0.0000     0.0000


1 VELOCITY= 15.00 KNOTS


      S (FT)      TENSION (LBS)    THETA (DEGREES)    X (FT)        Y (FT)
   YOUR SP. GR. FOR NEUT. BOUY. IN SALT WATER! 1.0247

     104.000          33.385          -1.472         103.966      -2.654
     208.000          65.770          -1.472         207.931      -5.325
     312.000          98.155          -1.472         311.897      -7.996
     416.000         130.540          -1.472         415.862     -10.668
     520.000         162.925          -1.472         519.827     -13.339
     624.000         195.311          -1.472         623.795     -16.010
     728.000         227.697          -1.472         727.763     -18.682
     832.000         260.083          -1.472         831.732     -21.353
     936.000         292.468          -1.472         935.700     -24.025
    1040.000         324.854          -1.472        1039.667     -26.696
    1144.000         357.240          -1.472        1143.629     -29.367
    1248.000         389.625          -1.472        1247.591     -32.039
    1352.000         422.011          -1.472        1351.553     -34.710
    1456.000         454.397          -1.472        1455.515     -37.381
    1560.000         486.783          -1.472        1559.477     -40.052
    1664.000         519.168          -1.472        1663.439     -42.723
    1768.000         551.554          -1.472        1767.401     -45.395
    1872.000         583.940          -1.472        1871.363     -48.066
    1976.000         616.326          -1.472        1975.324     -50.737
    2080.000         648.711          -1.472        2079.290     -53.408
    2184.000         681.097          -1.472        2183.265     -56.079
    2288.000         713.483          -1.472        2287.239     -58.750
    2392.000         745.869          -1.472        2391.214     -61.422
    2496.000         778.254          -1.472        2495.188     -64.093
    2600.000         810.640          -1.472        2599.163     -66.764
    2704.000         843.026          -1.472        2703.138     -69.436
    2808.000         875.412          -1.472        2807.112     -72.107
    2912.000         907.797          -1.472        2911.087     -74.779
    3016.000         940.183          -1.472        3015.062     -77.451
    3120.000         972.569          -1.472        3119.036     -80.122
    3224.000        1004.955          -1.472        3223.011     -82.794
    3328.000        1037.340          -1.472        3326.985     -85.465
    3432.000        1069.726          -1.472        3430.960     -88.137
    3536.000        1102.112          -1.472        3534.935     -90.808
    3640.000        1134.498          -1.472        3638.909     -93.480
    3744.000        1166.883          -1.472        3742.884     -96.152
    3848.000        1199.269          -1.472        3846.858     -98.823
    3952.000        1231.655          -1.472        3950.833    -101.495
    4056.000        1264.041          -1.472        4054.808    -104.166
    4160.000        1296.426          -1.472        4158.767    -106.838
    4264.000        1328.812          -1.472        4262.716    -109.509
    4368.000        1361.198          -1.472        4366.665    -112.181
    4472.000        1393.583          -1.472        4470.614    -114.853
    4576.000        1425.969          -1.472        4574.563    -117.524
    4680.000        1458.355          -1.472        4678.513    -120.196
    4784.000        1490.741          -1.472        4782.462    -122.867
    4888.000        1523.126          -1.472        4886.411    -125.539
    4992.000        1555.512          -1.472        4990.360    -128.210ILLEGAL ENT
RY TO JOBMN AT 000002

 JOB ERROR
```


THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
1 =INPUT DATA: DEFINE FILE(S)
1=DRSS


     INITIAL TENSION=    1.00 LBS
   SPECIFIC GRAVITY CONVERSION FACTOR=: 1.00


   S          DIAM       SPECIFIC   INTERMEDIATE
(FEET)      (INCHES)     GRAVITY    STEP SIZE

    0.0000     0.6500     0.7950     4.0000
 5000.0000     0.0000     0.0000     0.0000


1 VELOCITY= 20.00 KNOTS


      S (FT)      TENSION (LBS)    THETA (DEGREES)    X (FT)         Y (FT)
   YOUR SP. GR. FOR NEUT. BOUY. IN SALT WATER: 1.0247

CAUTION-ERROR IN DIFSYS
SOLUTION FOUND HAS RELATIVE ERROR=    0.17E-05
      104.000          58.489          -1.055          103.983      -1.905
      208.000         115.978          -1.055          207.965      -3.819
      312.000         173.466          -1.055          311.948      -5.733
      520.000         288.446          -1.055          519.909      -9.562
      624.000         345.937          -1.055          623.890     -11.476
      728.000         403.428          -1.055          727.871     -13.390
      832.000         460.919          -1.055          831.852     -15.305
      936.000         518.409          -1.055          935.833     -17.219
     1040.000         575.900          -1.055         1039.814     -19.133
     1144.000         633.391          -1.055         1143.802     -21.047
     1248.000         690.881          -1.055         1247.789     -22.962
     1352.000         748.372          -1.055         1351.774     -24.876
     1664.000         920.844          -1.055         1663.738     -30.618
     1768.000         978.335          -1.055         1767.726     -32.533
     1872.000        1035.824          -1.055         1871.713     -34.447
     1976.000        1093.309          -1.055         1975.700     -36.361
     2080.000        1150.793          -1.055         2079.684     -38.275
     2184.000        1208.278          -1.055         2183.658     -40.190
     2288.000        1265.762          -1.055         2287.633     -42.104
     2392.000        1323.246          -1.055         2391.607     -44.018
     2496.000        1380.731          -1.055         2495.582     -45.932
     2600.000        1438.215          -1.055         2599.557     -47.846
     2704.000        1495.699          -1.055         2703.531     -49.761
     2808.000        1553.184          -1.055         2807.506     -51.675
     2912.000        1610.668          -1.055         2911.480     -53.589
     3016.000        1668.153          -1.055         3015.455     -55.503
     3120.000        1725.637          -1.055         3119.430     -57.417
     3224.000        1783.122          -1.055         3223.379     -59.332
     3536.000        1955.574          -1.055         3535.328     -65.075
     3640.000        2013.059          -1.055         3639.303     -66.989
     3744.000        2070.543          -1.055         3743.277     -68.904
     3848.000        2128.028          -1.055         3847.252     -70.818
     3952.000        2185.512          -1.055         3951.227     -72.733
     4056.000        2242.997          -1.055         4055.201     -74.648
     4160.000        2300.481          -1.055         4159.191     -76.562
     4264.000        2357.965          -1.055         4263.191     -78.477
     4368.000        2415.450          -1.055         4367.191     -80.391
     4472.000        2472.934          -1.055         4471.191     -82.306
     4576.000        2530.418          -1.055         4575.191     -84.221
     4680.000        2587.903          -1.055         4679.191     -86.135
     4784.000        2645.387          -1.055         4783.191     -88.050
     4888.000        2702.872          -1.055         4887.191     -89.964
     4992.000        2760.356          -1.055         4991.191     -91.879ILLEGAL ENT
RY TO JOBMN AT 000002

 JOB ERROR
```


THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

APPENDIX I

APPENDIX I

CAPSTAN CHARACTERIZATION

APPENDIX I

CAPSTAN CHARACTERIZATION

1. Adapter, RF Cable, Conn Interface and D02387-001 Component Arrgt Mx - BRR Performance IAW NUSC SPEC A-342/4141-282 6¼" overall length

2. Amplifier, Radio Frequency, Connector Interface and Chassis Arrgt AM - BRR NUSC D02386-001

3. RF Cable Assemblies Type I, CG -/B, ND Type II, CG-/B NUSC D02388

   D02378-001

   Fabrication IAW NUSC SPEC C-342/4141-278

   - Assumed flexible adapter and amp housing assys ref 3-II-B10
   - Assumed that the antenna element 4" OD x 4 ft lg is also flexible
   - Design parameters:
     - Ref arrays @ 40:1 ratio $\{r_{bend}$ vs $r_{cable}\}$ yields ratio x 100 = % stretch

       50% stretch is maximum allowable Kevlar stretch
     - Ref tow cables @ 400:1 ratio

       $\{r_{bend}$ vs $r_{largest}\}$ wire dia reinforced
     - *** Rel. bending service life $\alpha \frac{D}{d}$ Ratio
     - *** Str. Efficiency $\alpha \frac{D}{d}$ Ratio

   ∴ Select 16.1 for Dias > 3" 16 x 3 = 48

   & Select 80.1 for Dias < 1" 80 x .65 = 46"

   or -- |48" PD Capstan Drum max allowable|

5. a. Per Vol, I UCHS, Fig. 2-1, Bending in % elongation, = $dr_{/ds}$ x 100. Where d_r = dia. reinforcement in the cable and ds = sheave dia.

   b. Per Fig. 1, The Relative Bending Service Life Factor @ D/d = 16 vs D/d = 12 = 1.875X

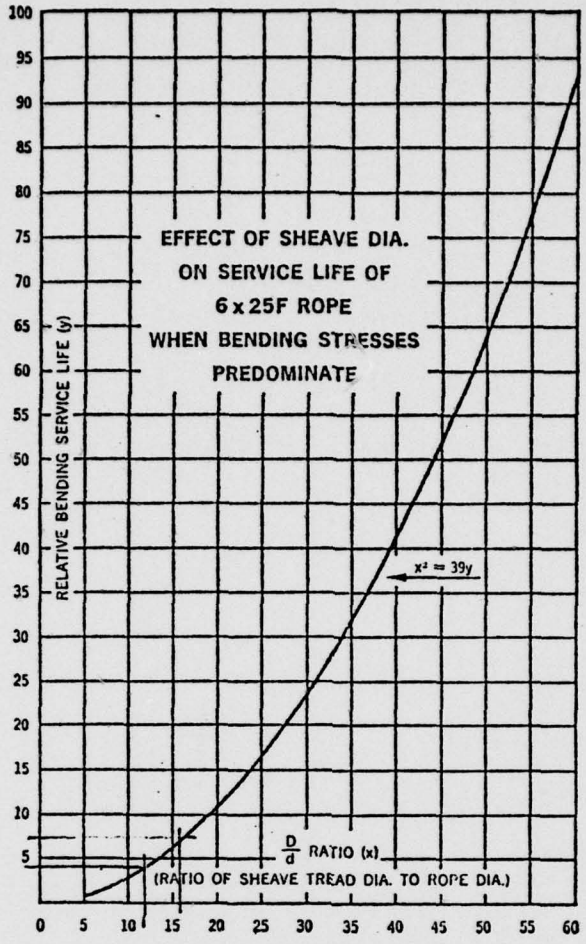


Figure 1

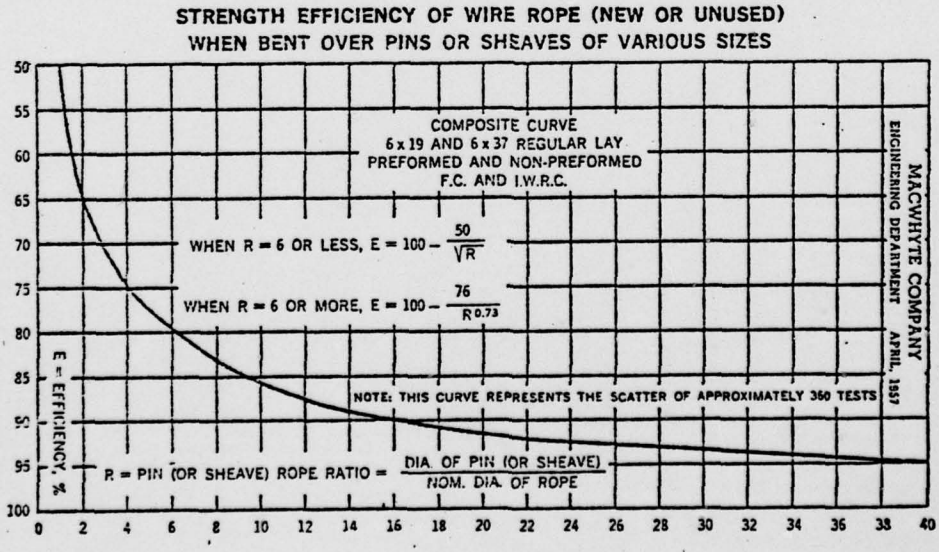
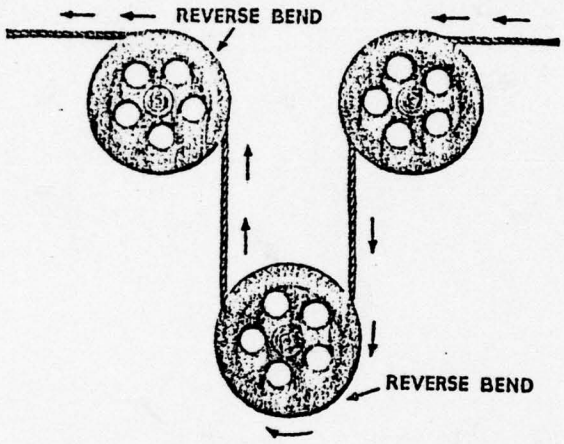


Figure 2

Reverse Bends

Years of experience and many tests have proved that reverse bending and excessive wire fatigue reduces rope life as much as 50%.



Where reverse bending cannot be eliminated, use the largest sheaves possible and place them as far apart as you can. By getting the MAXIMUM distance between reverse bends, you reduce fatigue—provide for longer service.

Keep sheaves aligned, too. Countless rope dollars have also been lost because sheaves are out of line.

You can detect misalignment by uneven groove wear. Keep sheaves in line. You'll save money.

MACWHYTE WIRE ROPE

Reserve Strength of Ropes

Ratio of Outer Wires and Inner Wires to Total Area

It is sometimes desirable to know what percent of the strength of a rope is contained in the inside wires, i.e., those wires that do not become worn from contact with the sheaves, drum, etc. Table below gives the reserve strength of these wires.

Of the total metallic area of a rope, the ratio of the inside wires of the strands to that of all the wires may be considered as the approximate reserve strength of the rope if it is well lubricated and free from corrosion.

Classification	Constr.	Total No. of Wires	No. of Outside Wires	Ratio of Outside Wires to Total	Reserve Strength of Inside Wires
One Size Wire Group	3 x 7D	21	18	99.8%	.2%
	5 x 5D	25	20	95.0%	5.0%
	5 x 7D	35	30	83.9%	16.1%
	6 x 7D	42	36	84.0%	16.0%
	6 x 8D	48	42	77.2%	22.8%
	6 x 12D	72	54	76.3%	23.7%
	6 x 19D	114	72	61.1%	38.9%
	6 x 37D	222	108	47.2%	52.8%
	6 x 37W	222	108	43.6%	56.4%
	18 x 7D	126	72	53.5%	46.5%
Seale Group	3 x 19G	57	27	68.6%	31.4%
	6 x 17G	102	48	74.1%	25.9%
	6 x 19G	114	54	67.3%	32.7%
	6 x 31G	186	72	57.3%	42.7%
	6 x 36G	216	84	51.8%	48.2%
	6 x 37G	222	90	50.8%	49.2%
	8 x 19G	152	72	67.8%	32.2%
	8 x 19G Elev.	152	72	66.6%	33.4%
Filler Group*	6 x 21F	126	60	63.8%	36.2%
	6 x 25F	150	72	56.8%	43.2%
	6 x 29F	174	84	51.1%	48.9%
	6 x 36F	216	84	51.0%	49.0%
	6 x 41F	246	96	46.3%	53.7%
	6 x 43F	258	108	43.6%	56.4%
	6 x 46F	276	108	42.2%	57.8%
	8 x 21F	168	80	62.7%	37.3%
	8 x 25F	200	96	55.5%	44.5%
Warrington Group	6 x 19E	114	72	58.5%	41.5%
	6 x 19E Elev.	114	72	57.6%	42.4%
	6 x 31E	186	96	49.6%	50.4%
	8 x 19E	152	96	57.2%	42.8%
	8 x 19E Elev.	152	96	57.6%	42.4%
Multiple Fiber Center Group	6 x 12R	72	72	100%	.0%
	6 x 24D	144	90	62.1%	37.9%
	6 x 24E	144	96	55.2%	44.8%
	6 x 42D	252	216	84.1%	15.9%

Ratios given are for ropes having Fiber Core.
*Filler wires were included in calculating the ratios for filler construction.

Figure 3

c. Per Fig. 2, The Relative Strength Efficiency @ D/d = 16 vs D/d = 12 = 1.03X

d. Per Fig. 3, Reverse Bending can reduce cable life by as much as 50%

e. Comparison to existing BRA-24 traction device

@ D = 12", $RBSL_{.65\ Dia} = 10$, for D/d = 18.46

@ D = 26", $RBSL_{.65\ Dia} = 77.5$, for D/d = 55.36

@ D = 48", $RBSL_{.65\ Dia} = 120_{(est)}$, for D/d = 73.85

f. Per Fig. 2-1, UCHS, Load in % Breaking Str @ 2% for Kevlar Reinforcement type 49 or 29 cords should be ≤ 25% Breaking Str.

6. a. Calculation of No. Grooves reqd. per Euler Relation

$$\frac{T_o}{T_i} = e^{\mu\alpha} \qquad \text{where } \mu_{est} \geq .25;\ \alpha = ?$$

@ $T_o = 3000 \rightarrow 6000\#_f$ and T_i (storage assy imposed load) $= 100\#_f + \Delta F = 100 \begin{matrix} 1000 \\ / \\ 0 \end{matrix}$

$e^{\mu\alpha}$ reqd =

	T_o @ 3000#$_f$/T_i		T_o @ 6000#$_f$/T_i	
T_i#$_f$		Log_e		Log_e
100	30.0	3.401	60.0	4.094
200	15.0	2.708	30.0	3.401
300	10.0	2.303	20.0	2.996
400	7.5	2.015	15.0	2.708
500	6.0	1.792	12.0	2.485
600	5.0	1.609	10.0	2.303
700	4.28	1.454	8.56	2.147
800	3.75	1.322	7.50	2.015
900	3.33	1.203	6.66	1.896
1000	3.0	1.099	6.00	1.792

where $\log (T_o/T_i) = \mu\alpha$

& $\alpha = \frac{2\pi}{360}$ (No. degrees)

or .01745 (No. degrees)

& μ = .25; .40; .55

Log_e Value		No. Deg. reqd @ μ = .25		No. deg. reqd @ μ = .40		No. deg. reqd @ μ = .55	
3.401	4.094	779	938	487	586	354	426
2.708	3.401	621	779	388	487	282	354
2.303	2.996	528	687	230	429	240	312
2.015	2.708	462	621	289	388	210	282
1.792	2.485	411	570	257	356	187	259
1.609	2.303	369	528	230	330	168	240
1.454	2.147	333	492	208	308	151	224
1.322	2.015	303	462	189	289	138	210
1.203	1.896	276	435	172	272	125	198
1.099	1.792	252	411	157	257	114	187

6. b. Calculation of No. Grooves reqd per $100\#_f$/linear ft cable shear stress criteria;

Cir = π (Dia x 4') = $12.57'/360^\circ$

$\therefore$ for $3000\#_f$; $30'/12.57' = 2.387$; x $360^\circ = 859.2^\circ$

& for $6000\#_f$; $60'/12.57' = 4.774$; x $360^\circ = 1718.4^\circ$

c. Conclusions:

- The $100\#_f$/linear ft cable shear stress criteria is the design driver by a factor > 2 x! (@ $T_i/T_o = 10$; μ= .40; & $T_o = 6000\#_f$)
- @ 180° increment for a Double Drum Capstan Configuration, we would require 4.77 grooves driving surface @ $3000\#_f$ & 9.54 grooves driving surface @ $6000\#_f$
- @ 360° increments for a Single Drum Capstan Configuration, we would require 2.38 and 4.77 wraps respectively driving surface

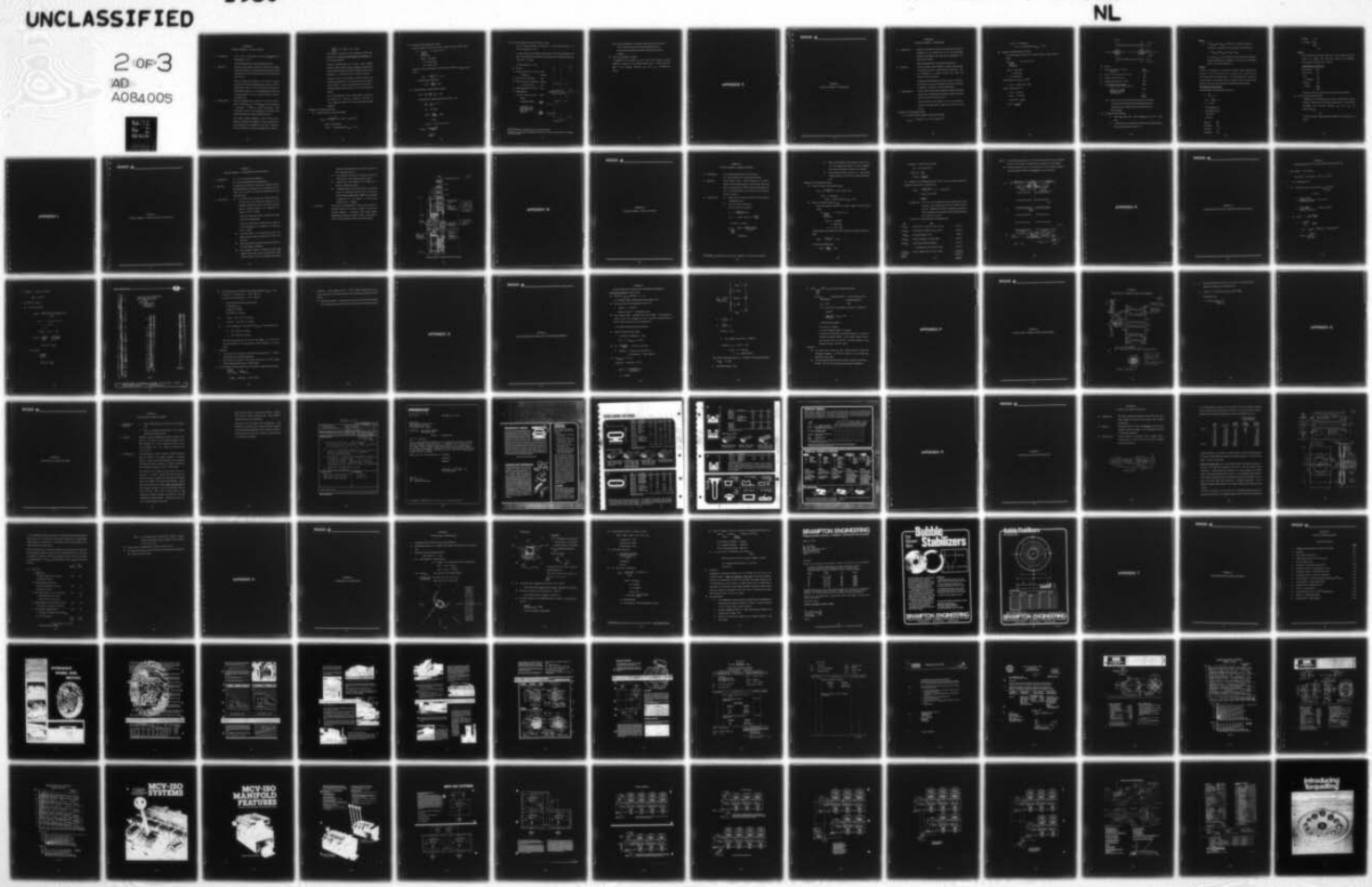
APPENDIX J

APPENDIX J

STORAGE ASSEMBLY - CHETSA CONCEPT

AD-A084 005 GOULD INC GLEN BURNIE MD CHESAPEAKE INSTRUMENT DIV F/G 13/10.1
DEPLOY/RETRIEVE STORAGE SYSTEM (DRSS). VOLUME II. PART II. COMP--ETC(U)
1980 N00039-79-C-0329
UNCLASSIFIED NL

2 OF 3
AD
A084005



APPENDIX J

STORAGE ASSEMBLY - CHETSA CONCEPT

- **Configuration** — OD > > FLG to Flg Spacing (to permit free-wind due to fleeting angle $< 2.5^{o}$).

  Barrel Sizing sufficient to minimize bending stresses.

- **Operation:** — Minimize windup tension, sufficient to assure snug wrapping, yet provide assistance to Deploy/Retrieve Mechanism Tension established by a const. torque motor, where max tension at the first wrap P.D.

  Minimum tensions also necessary: (1) due to B.C.A. cable lay cross-over point contact loading/potential cold flow of B.C.A. polyethylene jacket; (2) assure that cable burying does not cause takeoff locking -- i.e., the Deploy/Retrieve Mech. has > tension capacity to pull an individual "buried" wrap from the Storage Assy.

- **Considerations:** — Must accommodate large S.A. inertia forces to accel. the S.A. from $0 \rightarrow 200\ FPM_{(reqt)}$; $0 \rightarrow 400\ FPM_{(goal)}$ such that cable sag is eliminated. Therefore requires proportional speed accel./decel. control of the Deploy/Retrieve Mechanism OR, provide large peak del. torque to accelerate the S.A.

  From Cable Analysis, Appendix G, with 0.65 Dia. B.C.A. Modulus of Elasticity @ $17{,}882\#_f/in^2$, and at allowable loading of $100\#_f$/linear ft; elongation is .0169 in/in. Assuming a 36" min. bend radius for the barrel, elongation due to bend is:

$$\frac{d_{cable}}{d_{barrel}} \times 100 = \frac{.65}{36} \times 100; = \underline{.0181}$$

This implies an inherent S.A. shear loading (or tension capability) which is 2.97X less than imposed by the BRA-24 with its 12" barrel Diameter!

However, characterization of the point contact loading imposed at cable crossover dictates a much lower loading such that the jacket durometer of 85 Shore A ±10% limitation is not exceeded, i.e., < .005" out-of-round is imposed on the cable.

Assuming 6 linear inches crossover overwrap @ .005" max deformation yields .692 $in.^2$. By vector sums, over 6" yields a 36.4$\#_f$ vertical, or normal force distributed over .692 $in.^2$ -- per 100$\#_f$ windup tension increment, or 52.6 psi compression loading.

From ASTM D2240-64T, 1964 w/.79mm probe dia., and Force, gms, equal to 56 + 7.66 H_A -- where H_A = 85 Shore A, yields 1.325$\#_f$ per .00076 $in.^2$ or 1744 psi compression loading capability.

Development of Configuration Sizing:

(a) Overall Vol. Reqd: (Low Tension Windup)

$$Vol_{ft^3} = \left(\frac{\pi \times (O.D.')^2}{4} \times (c + 5")\right) \quad /1728\ in.^3/ft^3$$

where c = Flg. Spacing

& $O.D.^1$ = Cable Storage $O.D._{reqd}$ + 4" F.S.

(b) Sizing of the Cable Storage O.D. Reqd:

From Reel Capacity Charts, with 'k' equal to approx. .568 for 5/8 Dia^{+} Cable,

& $L_{\text{storage cap, ft @ 100\% eff.}} = (A + B) \times A \times C \times K$

where A = Flg. Depth

& B = Barrel Dia.

or A = (O.D. - B)/2

Assuming 75% wrap efficiency for free-wind and setting $L_{\text{storage reqd}}$ to 5000',

$$5000' = \frac{O.D.^2 - B^2}{4} \times .426\ c$$

& Assuming a 36" Barrel Dia.,

$$\therefore O.D.^2 = \frac{5000'}{.1065\ c} + 1296$$

(c) Characterization of Fleeting Angle required:

$$< 2.5^{o} \simeq \text{Ratio } \frac{1.25}{30} = \frac{1}{24} = C/48$$

& Assuming Max. Fleeting Angle Traverse Dist $\leq$ 10';

$$\therefore \frac{C}{48} = \frac{X}{120},\text{; or } X = 5"$$

& C = 2X or $\underline{\underline{10"}}$

$$\therefore O.D.^2 = \frac{5000}{.1065C} + 1296$$

$$= 5991$$

or $O.D.^1 \simeq 78.0" + 4"$ F.S. = 82"

$$\& \text{ Vol}_{ft^3} = \frac{.785 \times 6724"^2}{1728}$$

$$= \underline{\underline{45.82}}\ ft^3$$

(d) Est. of Ant. Element Lump Cap.; 4" O.D. x 4 ft lg:

As Vol. of cable, available = 2/3 (40.82 ft^3) = 27.23 ft^3 and each lump ≃ .35 ft^3; Vol. reqt./lump ≃ 1.3%.

As orig. sizing for the Storage Assy assumed a 75% wrap efficiency, with 85% → 95%* efficiency estimated as a best estimate of obtainable efficiency, 10%/1.3% = 7.7 lumps.

If 1 lump/1000'; F.S. = 1.54.

(e) Wt. Est.

- Barrel, 36" OD x 15" x 1/4" thk = 127#
  + Stiffeners = 40# est.
- Hub, 5" OD x 15" 3/4" thk = 53#
- Shaft, 4" OD x 15" Lg (hollow) = 69# est
  + 3 1/2" OD x 8" lg = 23#
- *Flg Plates 82" OD x 1/4" thk = 791#
- *Flg Stiffeners

@ 12 in. - 78" lg, 4 x 2 Tee = 507#

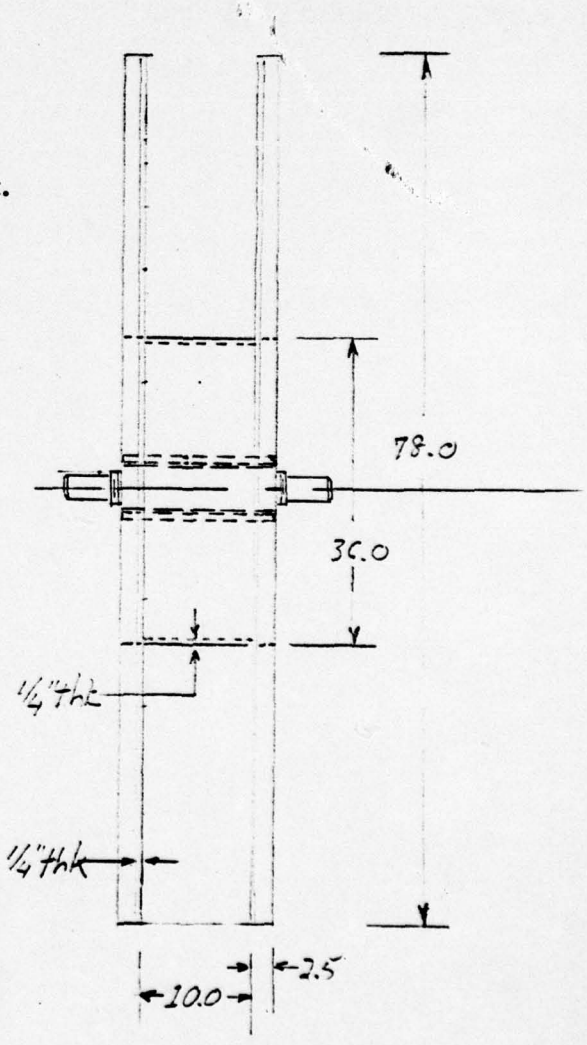
6.5#/ft

+ Stiffeners @ 25% 127#

1737#

+ Misc. Str. -- i.e. Brg. Supports, Slip Ring, Assy; Pawl Steps, etc. 150#

1887#



*Current "CHETSA" testing indicates 90 → 95% efficiency!

*Lightweight Technology (Fiberglass/Aluminum, etc.) Mat'ls could reduce the Storage Assy wt by ≈900#

Note--Config. modification to incorporate the Storage Assy Drive Motor within the Barrel Envelope improves packaging efficiency -- similarly the shaft support(s) could be brought within the barrel envelope.

(f) Drive Characterization: 200 FPM

A Hagglunds 0555 @ 46#/100 psi hyd. motor w/.150 Gal/Rev. provides capability to operate the S.A. @ $300\#_f$ windup tension -- or 978 psi & 21.22 RPM x .150 or 3.18 gpm. Assuming η_{HM} = .95 & η_{vol} = .93 yields 2.06 HP_{reqd}.

APPENDIX K

APPENDIX K

STORAGE ASSEMBLY - W/LEVELWIND

APPENDIX K

STORAGE ASSEMBLY - W/LEVELWIND

- **Configuration:** Geometry relationship of Barrel Dia., Flg spacing and Flg OD undefined, i.e., no limitation per se, as the levelwinding mechanism establishes ideal cable lay as a function of the geometry relationship.

  Barrel Sizing sufficient to minimize bending stresses.

- **Operation:** Minimum windup tension, sufficient to assure snag wrapping, yet provide assistance to Deploy/Retrieve Mechanism. Tension established by a constant torque motor, where max tension at the first wrap P.D.

  Levelwind provides capability to achieve higher windup (storage) tensions over that of the CHETSA type, due to uniformity of cable lay. Can achieve ≃ 100% wrap efficiency.

- **Considerations:** Inertia effects dictate either proportional speed accel./decel. control of the Deploy/Retrieve Mechanism, OR, provide large peak del. torque to accelerate the S.A.

  Antenna Element Lump Storage for 4" OD x 4' lg limited to the outer wrap layer (6th) or approx. the last 833 ft of the B.C.A.

Deployment of Configuration Sizing:

(a) Overall Vol. Reqd. (Medium → High Tension Windup)

$$Vol_{ft^3} = \left(\pi \times (O.D.')^2 \times (C + 7")\right) / 1728\ in.^3/ft^3$$

where C = Flg. Spacing

& O.D.' = Cable Storage OD_{reqd} + 4" F.S.

(b) Sizing of the Cable Storage O.D. Reqd.:

From Reel Capacity Charts with 'k' equal to approx. .568 for 5/8 Dia + Cable,

& $L_{\substack{\text{storage} \\ \text{cap, ft} \\ @\ 100\%\ \text{eff}}}$ = (A + B) x A x C x K

where A = Flg. Depth

B = Barrel Dia.

or A = (O.D.-B)/2

Assuming that B = 36 in.; & L = 5000'

$\therefore$ $O.D.^2$ = (5000'/.142c) + 1296

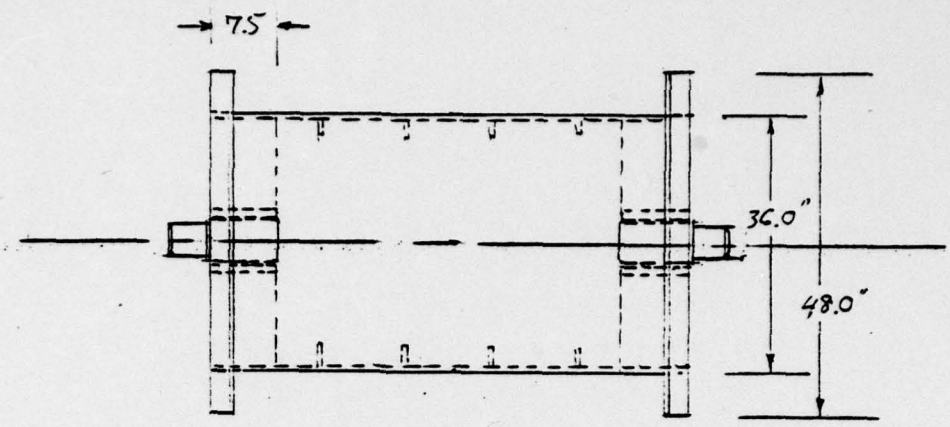
Setting c equal to 60"; 72"

$\therefore$ O.D. = 44"; 42.5"

& $O.D.^1$ = 48"; 46.5"

$\therefore$ Select $O.D.^1$ @ <u>48"</u>

& Vol = <u>70.13 ft^3</u>



(c) Wt. Est.

• Barrel, 36" OD x 67" x 1/4" thk	=	567#
+ Stiffeners		80# est
• Hubs, 5" OD x 7.5" x 2 in.) x 3/4" thk	=	53#
• Shafts, 4" OD x 11.5" x 2 in.	=	87#
• Flange Plates, 48" OD x 1/4" thk		271#
• Flg. Stiffeners/Barrel Support @ 12 in. - 7.5" x 15.5" x 1/2" thk		209#
+ Misc. Str -- i.e. Brg Supports, Slip Ring, Pawl Steps, etc.		150#
		1417#

Note -- Config. modif. to incorporate the Storage Assy Drive Motor within the Barrel Envelope improves packaging efficiency -- similarily the shaft support(s) could be brought within the barrel envelope.

(d) Levelwind Characterization:

- One Storage Drum Rev = axial displacement of .65 in. + clearance.
- A LeBus Barrel is recommended w/Starting & Reversal Ramps to assure proper cable lay for layers 2 → 6.

Option 1

- P. Dia_{driver}/P. Dia_{pinion} x RPM of S.A. = RPM of Levelwind

  Assuming a 1" Lead Ball Scw. Assy. requires .65 Rev^3/S.A. Rev.

  $\therefore$ $P.D_{driver}/P.D_{pinion} = .66_{min} \rightarrow .68_{max}$

  As min $P.D._{driver}$ must be selected to accommodate a Timing Belt having sufficient tension capability to overcome the cable loading, assume 8" & 12" PDs respectively.

Option 2

A 2" Dia., 1" Lead Ball Scw Assy similar to a Warner R-2001, @ $2000\#_f$ Load has an est. 20×10^6 in. travel life. As 12 x 60" travel x 2 = 1 dep/ret cycle or 1440 inches travel x 540 cycles/mission $\simeq .8 \times 10^6$ inches/mission -- yields a 25 mission lifetime. This approach requires a separate hyd. drive torque motor with prop. flow accel. valve acting as the cable positioning mechanism.

Characterization & Weight Est:

Ref p297 Shigley - Mech Engr Des, 2nd Ed, 1972

$$T_o = \frac{Fl}{2\pi} \eta_M = .9$$

@ F = 1000#; l = 1"

T_o = 14.74"#

Use SAMM M15-21

@ 19.92"#/100 psi &

1.52 $in.^3$/rev

& 21# wt

Ball Scw	60#
M15-25 @	21#
Accel Vlv	5#
36" Sheave	45#

Carriage	15#
L.V. Supports	60#
	206#

OR

Option 3

A twin NORCO Ball Reverser BR2100 w/3" Lead @ .667x 21.22 RPM yields up to 1900#$_f$ Axial Load Cap, driven by the described P.D.$_{driver}$/P.D. pinion @ a .22 → .23 ratio.

Characterization & Weight Est.:

Ball Reversers	240#
Driver/Driven	60#
Belt	5#
L.V. Supports	40#
36" Sheave	45#
Carriage	40#
	430#

Conclusion: Optimum Levelwind Drive Config. must be evaluated.

(e) Drive Characterization; 200 FPM

A Hagglunds 1155 @ 69#/100 psi hyd. motor, w/.225 gal./Rev provides capability to operate the S.A. @ 1000#$_f$ windup tension -- or 2174 psi and 21.22 RPM x .225 or 4.77 GPM. Assuming η_{HM} = .95 & η_{Vol} = .93 yields 6.85 HP$_{reqd.}$

OR

A PMI Solid State Torque Ring Motor Model 3/1.5 can provide up to 1500'#.

APPENDIX L

APPENDIX L

STORAGE ASSEMBLY - PRESSURE PROOF ACCESS TRUNK

APPENDIX L

STORAGE ASSEMBLY - PRESSURE PROOF ACCESS TRUNK

- Configuration: #1 -- S.A. w/Levelwind Per Appendix J;

  #2 -- Barrel Stuffing Concept Per Appendix M;

- Operation: Provides system capability to operate w/o dynamic seals IF the Deploy/Retrieve Mechanism can be integrated into the Trunk. B.C.A. access for maintenance available from within the pressure hull.

- Considerations:

  (a) Per Transfer Mech. Summary, the Traction Belt Drive, Traction Clamp, and Single Drum Capstans are non-adaptable configurations which would impact seriously upon the System Envelope & Wt Constraints, i.e., projects > 85 ft^3 & > 6000#.

  The Laminar Fluid Mech could be integrated into either the #1 or #2 Configurations.

  The Direct Windup Mech., (concept only) is implicit in the #1 Configuration -- by extension of its Load Capacity to 3000#.

  (b) Assume 600 PSID as a max opn'l pressure reqts --with higher non-opn'l pressures isolated by the F.S.S.S. and Hull Valve

  (c) Must accommodate the positive buoyancy of the B.C.A. if the #2 Config. is considered.

  (d) Must establish method to Rethread the BCA each Dep/Ret cycle as opn. requires that the F.S.S.S. or Hull Valves be closed. If this is not desirable, the pressure

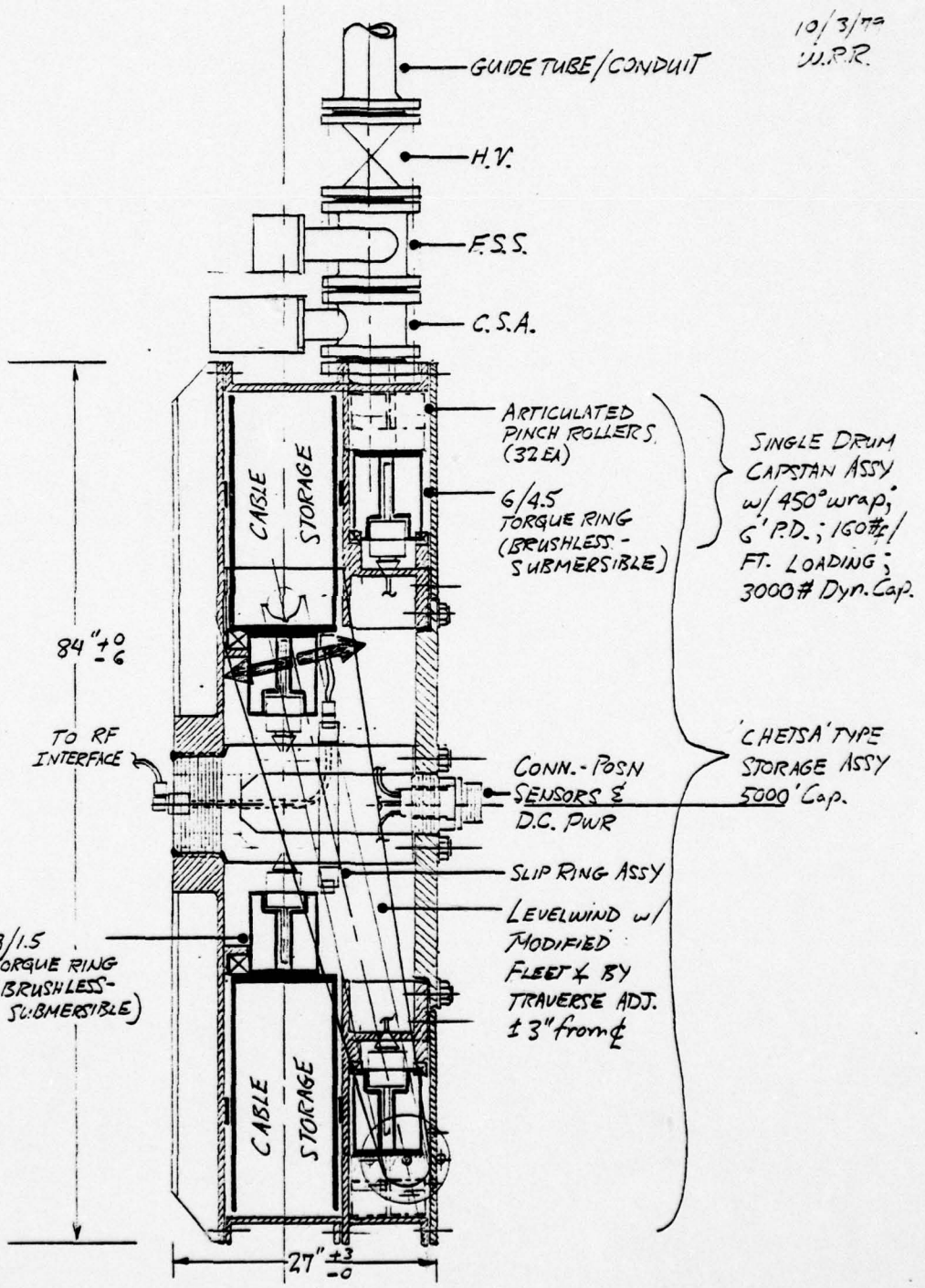
capability requirements dictate a further increase in wt by at least a factor of 2X.

(e) Must establish a method for end retrieval of BCA for maint. access -- incl. re-insertion into the trunk.

(f) Assume 60% wrap efficiency for Config. #2 in Cap./Vol. sizing reqt. analysis.

(g) A pressure vessel, 1/2" thk wall, 48" ID, 1" thk end bell assys, 12 in. reinforcing rings 5/8" thk, & 72" between end bell flanges weighs approx. 5000# with an envelope of approx. 80 ft^3. This applies to a 200 psi opn'l capability @ F.S. = 5 ONLY!

- Conclusion: The extent of accommodation to config. reqts to be able to eliminate dynamic seals, does not appear to justify this particular approach -- particularly when several feasible approaches to sealing are possible. (Refer to Appendices N thru S.) Finally, Installation Costs are severely impacted.



Storage Assembly - Pressure Proof Access Trunk

APPENDIX M

APPENDIX M

STORAGE ASSEMBLY - BARREL STUFFING

APPENDIX M

STORAGE ASSEMBLY - BARREL STUFFING

- Configuration: #1 -- Rotating Barrel w/B.C.A. injector device.

  #2 -- Static Cage w/B.C.A. rotating injector device.

- Operation: "Zero" windup tension. Positive buoyancy of the B.C.A. requires inverted Barrel/Cage to permit buoyant forces plus BCA wrap positioning to achieve a loose wrap storage of the BCA. If the Barrel/Cage is not inverted, a "dry" storage of the BCA is possible.

- Considerations:

  (a) Optimum B.C.A. storage concept due to lowest possible storage/wrap forces.

  (b) 'O' B.C.A. twist for Config. #1;

  360° twist/12.56' for Config. #2

  As $\theta = \frac{T,"\#\ x\ l,\ in}{G^* \times J}$; or @

  $\theta = 2^{\pi}$, $= 12.56' \times 12"/ft$ & $J = \frac{\pi d^4 BCA}{32}$

  $= .0175\ in.^4$; $T = 13.06"\#$

  & $\tau_{\substack{Max\\Shear\\Stress}} = \frac{T \times r}{J} = \frac{13.06"\# \times .325\ in.}{.0175\ in.^4}$

  $= 242.6$ psi !*

*G = 17,882 psi assumed value by Cable Test - Appendix G. This needs to be tested!!

(c) Easily accommodates Antenna Element Lumps 4" OD x 4' lg. (#2 conditionally requires ≈ 90° twist capability over 4' and 25# tension to conform to a 2' Radius!)

(d) Recommended minimum wrap dia is 4'. Assume 60% storage efficiency for Envel./Vol. requirements definition.

Development of Configuration Sizing:

(a) Overall Vol. Reqd: (Low Tension Windup)

$$Vol_{ft^3} = \left(\frac{\pi \ (O.D.'^2)}{4} \times (c + 7") \right) \ / 1728 \ in.^3/ft^3$$

where c = Flg Spacing

& O.D.' = Cable Storage $O.D._{reqd}$ + 2" F.S.

(b) Sizing of the Cable Storage $O.D._{reqd}$:

From Reel Capacity Charts, with 'k' equal to approx. .568 for 5/8 Dia Cable,

$$\& \ L_{\substack{storage \\ cap, ft \\ @ 100\% \ off}} \approx (A + B) \times A \times c \times k$$

where A = Flg Depth

B = Barrel Dia.

or A = (O.D. - B)/2

Assuming 60% wrap efficiency for 'Zero' tension free winding and setting L = 5000',

$$5000' = \frac{O.D.^2 - B^2}{4} \times .341 \ c$$

& Assuming a 48" Barrel Dia.

$$\therefore \ O.D.^2 = \frac{5000'}{.0852c} + 2304$$

& Setting c = equal to 60"; 72"; & 84"

O.D. 57.5; 56.25; & 55.0

∴ Select O.D.' 60"

& $Vol_{ft}3$ = 109.6 ft^3

(c) Calcualtion of the Displacement, Ft^3 reqd if the S.A. located outside the pressure hull, but within the superstructure

$$Vol_{ft}3 = \frac{(O.D.^2 - ID^2)}{4} \times (c + 7) \quad /1728\ in.^3/ft^3$$

$$= 1296 \times .785 \times 67/1728$$

$$= 39.4\ ft^3$$

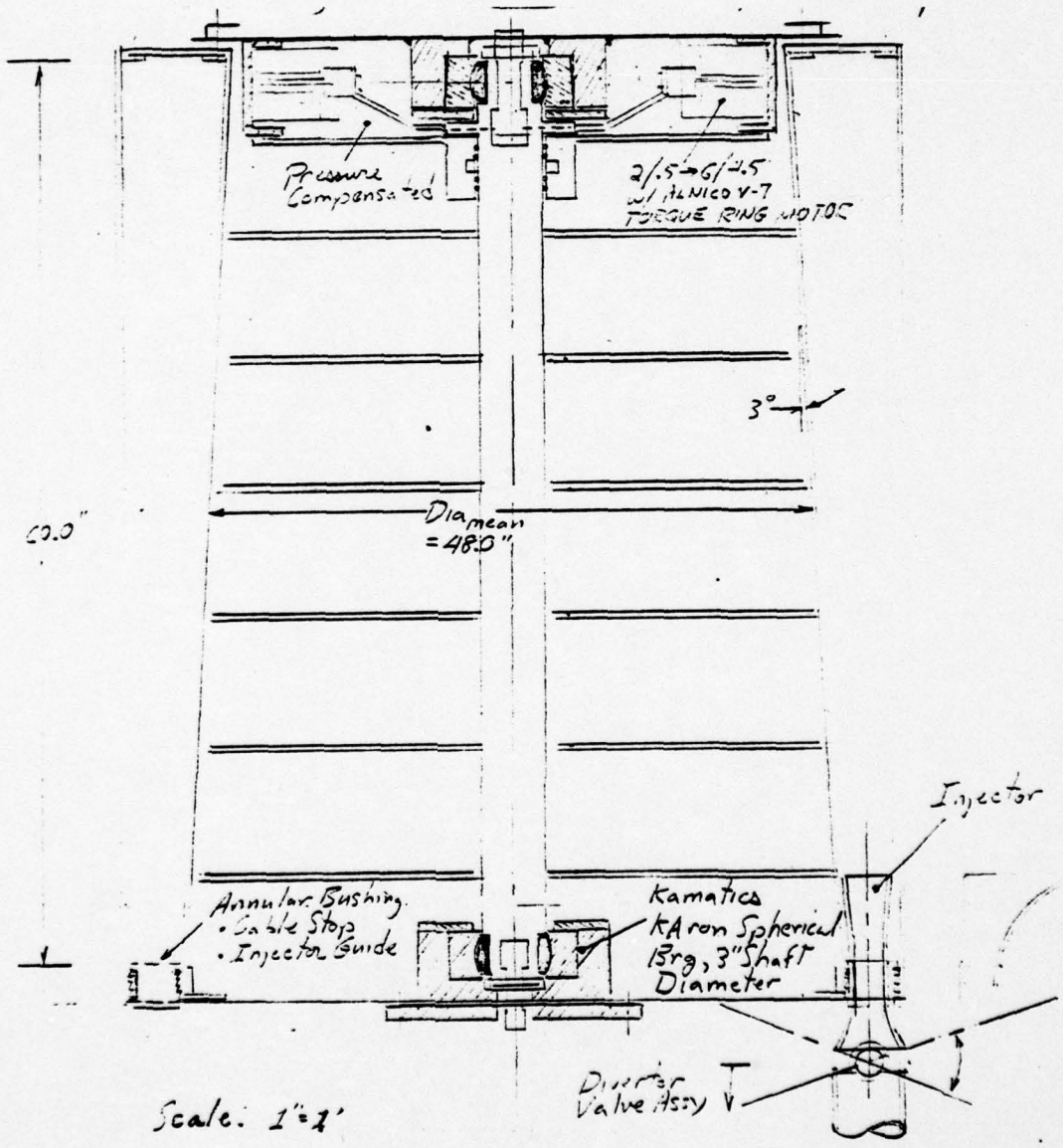
Consideration: As the S.A. is free flooded, the above envelope value is also too large -- and is ideally only that of the 5000' of BCA @ 11.52 ft^3 + Material Cubic Disp. of inner/outer shells, Drive Motor w/Pressure Comp. Housing & Brgs w/Support Housings; for an add'l Vol. of 13.4 ft^3.

Vol & Wt. Est - Material Basis for True Displacement:

Wt		Vol		
312.7#est	• Outer Shroud - 60" OD x 67" lg x 1/4" thk	=	3157 $in.^3$
253.0#est	• Inner Barrel - 48" $\overline{ID}$ x 60" lg x 1/4" thk	=	2526 $in.^3$
50.0#est	• Annular Bushing - 3" thk	=	509 $in.^3$
250.0#est	• Motor w/Housing - 3' OD x 8" deep	=	8179 $in.^3$
200.0#est	• Main Shaft w/Reinf. Rib Plates	=	1695 $in.^3$
	6 ea Plates, 1/4" thk & 6" OD x 60" lg	=	6104 $in.^3$
270.0#est	• Brg. w/Support Hsg - 14" OD x 6" deep	=	923 $in.^3$
1335.7#			23,093 $in.^3$
		=	13.4 ft^3

Note (1) If reverse Rotating Element in the PMI Torque Ring Motor, we can eliminate the DC Power Slip Ring. A Hydraulic Motor configuration is also possible.

(2) Differential Speed Curves must be generated to assure "positive stuffing" is always maintained Testing will be <u>essential</u> to verify the concept!



APPENDIX N

APPENDIX N

CHARACTERIZATION OF DYN. SEAL (NON-CONTACT) LEAKAGE

APPENDIX N

CHARACTERIZATION OF DYN. SEAL (NON-CONTACT) LEAKAGE

1. Dyn. Viscosity = Abs. Viscosity

$$\#_f - \text{Sec/Ft}^2 \times 32.16 \#_m \text{Ft}/\#_f - \text{Sec}^2 = \#_m/\text{Ft-Sec}$$

2. $1 \text{ cp} = .000672 \#_m/\text{Ft-Sec}$

3 (a) Kinematic Viscosity = Abs. Viscosity, $\frac{\mu_m, \#_m/\text{Ft-Sec}}{\rho, \#_m/\text{Ft}^3}$

$$= \nu, \text{Ft}^2/\text{Sec}$$

$$\text{or } - \frac{3049 \#_m/\text{Ft-Sec}}{.000672 \#_m/\text{Ft-Sec/cp}} = 4.537 \times 10^6 \text{ cp}$$

$$\& \quad \frac{4.537 \times 10^6 \text{ cp}}{78.9 \#_m/\text{Ft}^3 \text{ (est only)}} = 57506 \text{ cs, } \text{Ft}^2/\text{Sec}$$

4. As $\tau, \#_f/\text{Ft}^2 = \mu \times \left(\frac{du}{dy}, \frac{\text{Ft/Sec}}{\text{Ft}}\right)$

$$\therefore \quad \mu, \frac{\#_f - \text{Sec}}{\text{Ft}^2} = \frac{\tau}{du/dy}$$

$$\therefore \quad \mu_{dyn} = \mu_{abs}/g_c = 3049/32.16 = 94.81 \#_f\text{-Sec/Ft}^2$$

$$\therefore \quad 94.81 = \frac{\tau, \#_f/\text{Ft}^2}{du/dy, \text{Sec}^{-1}}$$

5. Assuming τ = 1.02 psi x 144 in^2/ft^2 ;

$$\frac{du}{dy} = 1.549\ Sec^{-1}$$

6. Evaluation of ΔPsi_{reqd}:

(a) It can be shown that;

$$\Delta\ Psi/Ft = \frac{4.352 \times 10^{-6} \times \rho \times Q, gpm \times \nu, cs}{d_{Hyd}^4}$$

where ρ = 78.9#$_m$/Ft^3 (est only)

ν = 57,506 cs

Q = ?

& $d_{Hyd} = D_2 - D_1$ = .003"

$$\therefore\ \Delta\ Psi/Ft = \frac{19.476Q}{(.003)^4} = \frac{19.476Q, gpm}{.81 \times 10^{-10}}$$

$$= 1.252 \times 10^{10}\ Q, gpm$$

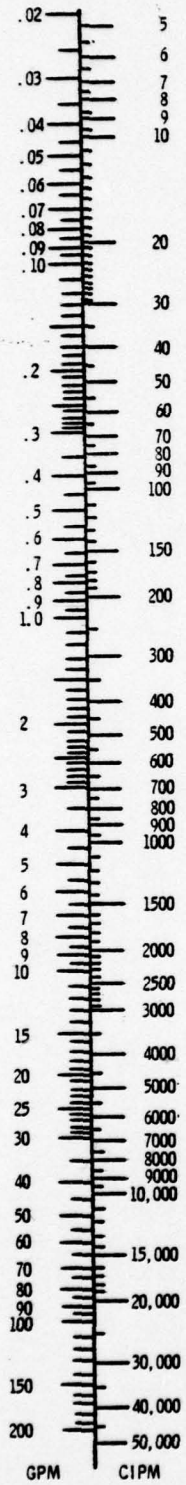
& @ .010 gap

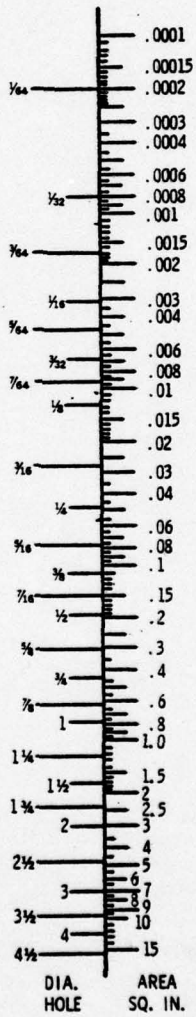
$$= \frac{19.476\ Q}{(.010)^4}$$

$$= 1.948 \times 10^{7}\ Q, gpm$$

ORIFICE PRESSURE DROP

$Q\ (GPM) = 24.12 \times A\ (SQ.\ IN.) \times \sqrt{PRESSURE\ DROP\ (PSI)}$
WHEN C=.6 AND SPECIFIC GRAVITY = .895
NO ALLOWANCE FOR VISCOSITY CHANGE
FROM:
$Q = C \times A \times \sqrt{2GH}$
WHEN: Q = FLOW IN CU. FT./SEC.
C = ORIFICE COEFFICIENT
A = AREA IN SQ. FT.
H = PRESSURE HEAD IN FT.





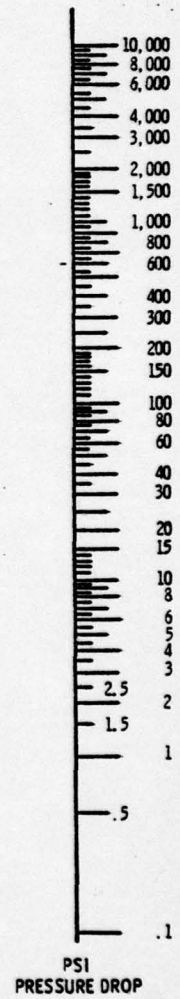


Figure 1

(b) Estimating Q, gpm from analogy to sharp-edged orifice; @ Δ Psi_{Max} = 1000

& A_{cs} @ .003 = .65 Cable Dia. x π x .003 = .0061 in^2

& A_{cs} @ .010 = .65 Cable Dia. x π x .010 = .0204 in^2

$\therefore$ From Orifice Pressure Drop Chart, Figure 1

at 1000 psid, & A_{cs};

@ .0061 $in.^2$ = 4.8 gpm

& @ .0204 $in.^2$ = 15.5 gpm

(c) $\therefore$ Δ Psi/ft = 6.01×10^{10} for .003" gap

& Δ Psi/ft = 3.02×10^{8} for .010" gap

(d) $\therefore$ For a .19" length for a wiper seal the ΔPsi_{reqd} = 63.16 X ΔPsi/ft, less

or, 9.52×10^{8} psi for .003" gap

& 4.78×10^{6} psi for .010" gap.

Note that these values are for .65 Dia. Cable ONLY. The Δ Psi will be directly proportional to the cable/antenna element diameters for all other values.

7. Conclusion:

- A viscous fluid seal is capable of "sealing" differential pressures > those that will be present for the required application.
- Many options with respect to seal annular clearances to 3X those selected indicate adequate safety margin > required depth.

8. Est. of Leakage, time, @ 1000 psid net, due to pressure compensation @ .010" gap.

$$\frac{1000 \text{ psi}}{4.78 \times 10^{6} \text{ psi}} = \frac{x}{15.5 \text{ gpm}_{max}}$$

Leakage = .00326 gpm = 0.752 $in.^3$/Min

9. Conclusion: a "zero leakage" seal @ < 5 $in.^3/hr$ (CHETSA specification) with a viscous liquid seal is theoretically possible with the following conditions: (@ .003" Annulus)

*** High Surface Tension > >Shear Stress @ 1.02 psi such that cable vel. effect @ the downstream wiper permits the fluid to be removed from the cable surface.

APPENDIX O

APPENDIX O

CHARACTERIZATION OF SEAL HEAT TRANSFER REQUIREMENTS

APPENDIX O

CHARACTERIZATION OF SEAL HEAT TRANSFER REQUIREMENTS

I. Finding Heat Generated: (Contact Type)

(a) Assuming $\mu_{contact}$ @ 200 FPM = .5 → 1.0

& Δ Psi @ opn'l depth = 600 psi; contact length equals 1 inch

(b) Assuming contact force loading equal to opn'l Δ Psi

$\therefore$ .65 dia. x π = 2.042 in.^{2}

600 psi x 2.042 in.^{2} = 1225.2#$_f$/linear inch

*** This is approx. 300X > allowable shear stress loading. The assumption is grossly in error--the seal itself must see an equivalent shearing force--yet keep its cable contact force to an acceptable value.

← of 4.082 psi allowable seal contact pressure

(c) Assume 3" minimum contact length

$\therefore$ 3 x 2.042 in.^{2} x 4.082#$_f$/in.^{2} = 25#$_f$

& @ $\bar{\mu}$ = .75$_{est\ only}$ ≈ 18.75#$_f$

(d) $HP = \frac{F \times V,'/min.}{33{,}000}$ = .11365 HP @ 200 FPM

& BTUs/min. = .11365 HP x 42.4 BTU/HP min.

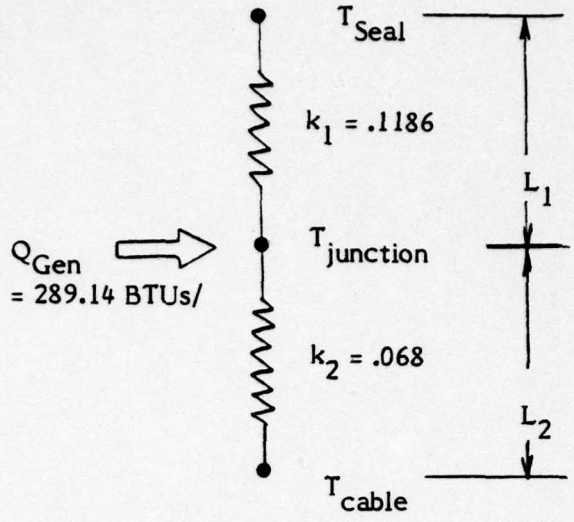
= 4.819 BTUs/min. = 289.14 BTUs/Hr

(e) $Q_{dissipated} = \bar{U} A_s \Delta T$

Assuming $\bar{U} \approx 2.0$ BTUs/Hr - Ft^2 ^oF

$$289.14 = 2 \left(\frac{6.126 \text{ in.}^2}{144 \text{ in.}^2/\text{Ft}^2} \right) \Delta T$$

$\therefore$ $\Delta T = 3398^oF$



$$Q = \frac{k_1 As_1}{L} \Delta T$$

$$Q = \frac{k_2 As_2}{L} \Delta T$$

where $k_2 \approx 1/2\, k_1$

& $As_2 \approx 48{,}000 \times As_1$, and As_1, = .04254 Ft^2

if Assume $L_2 \approx L_1$ = .06"/12 = .005'

$\therefore$ per ^{o}F; $Q \uparrow \approx 1$ BTU/Hr

& $Q \downarrow \approx 2768.2$ BTUs/Hr

Note - that for a liquid seal, assume $\mu_f \leq .01$ (equiv. to viscous drag coefficient)

& Q_{gen} = 75 x less

- Dyn Seal resistance $\leq 25\#_f$

(f) Find $Q_{\uparrow \text{cable heat sink}} = \frac{k\ As}{L}\ \Delta T_{est}$, by Order-of-Magnitude-Analysis

where k_{est} polypropylene = .068 BTUs/Hr-Ft$^{\circ}$F = 2.8×10^{-4} cal/sec/cm^2,$^{\circ}$C x 242.08 BTUs/Hr-Ft^2

L_{est} = .06" = .068

& A_s = 2.042 in.^{2} x 12 x 200 FPM x 60 min./Hr x 1 Ft^2/144 in.^{2}

= 2042 Ft^2

$= \frac{.068\ (2042)}{.06"/12"/Ft}\ \Delta T_{est}$ @ .1°F

= 2768.2 BTUs/Hr capability!

If L is less, Q↑ increases.

If Δ Temp is higher is higher Q↑ increases.

As there is a skin absorption 'transient' phenomenon -- a lower skin thickness is probably required -- with a higher junction temp to drive the heat flow, i.e., @ 10°F = 100X less thickness, & skin boundary thickness = .06"/100 = .0006"

Conclusion:

(a) The cable itself provides the best "cooling" means to assure seal temperature integrity. (A 10°F rise would be a most conservative estimate for worst case!)

(b) The final analysis should include the think film effects "wetted cable -- @ .0005 → .001" thk. This will drive up the Junction Temperature.

APPENDIX P

APPENDIX P

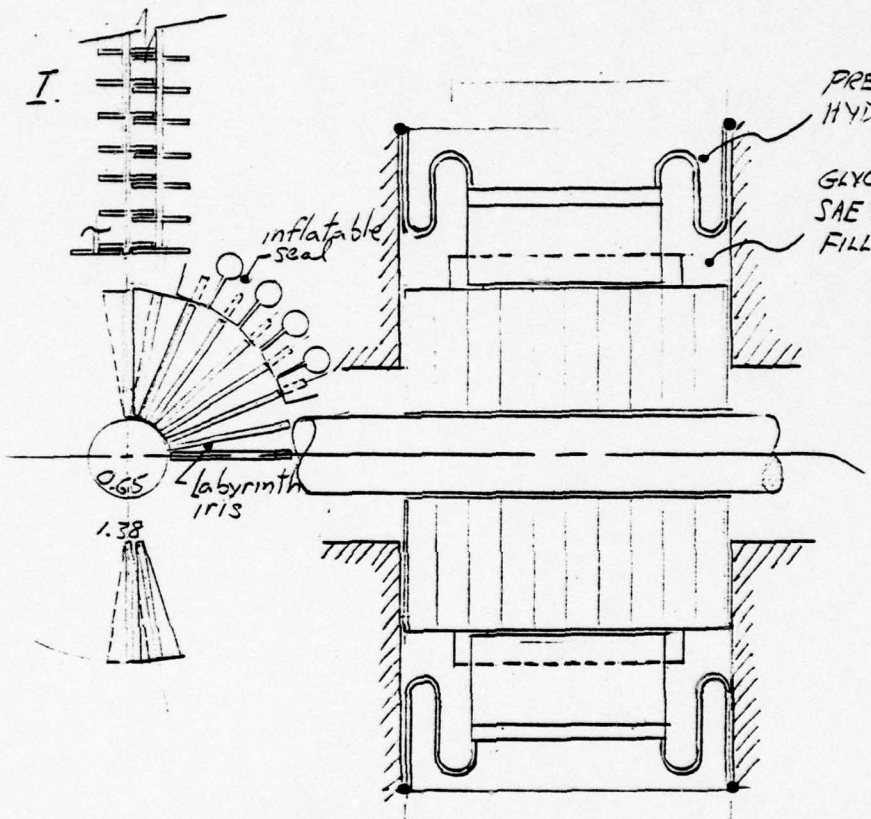
DYNAMIC SEAL, VARIABLE, ARTICULATED SEGMENT

APPENDIX P

DYNAMIC SEAL, VARIABLE, ARTICULATED SEGMENT

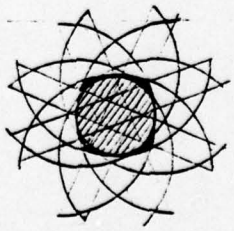
8/28/79
WRR

I.



Refer to SK 129E002
& to Appendix Q for Inflatable Seal Details

II.



4- lens iris : red
8- lens iris : green
1.38 O.D. max Dia
& 0.650D min. Dia

(Area reduction > 5X for 2X Nº lenses)

Refer to Appendix R

I. a. Filled with glycerine/or SAE 70 or 90 wt Lub. Oil. (very high viscosity)

Labyrinth iris Adiprene, or Monel (Duro 95A)

b. $\tau \#_f/Ft^2 = \mu_f, \#_f\ Sec/Ft^2 \times g_c, \#_m/\#_f\ Ft/Sec^2 \times \frac{du}{dy}$

where shear stress

$$\tau = \Delta\ Psi \times A_{cs}/(A_{\substack{plate \\ elem.\ surf}} \times 2)$$

APPENDIX Q

APPENDIX Q

DYNAMIC SEAL, VARIABLE, BLADDER

APPENDIX Q

DYNAMIC SEAL, VARIABLE, BLADDER

- Configuration Definition:
  1. Refer to DRSS Proposal p 3-46, Para. 3.6.2.1 and Figure 3-27.
  2. Refer to NAVSHIPS 0967-325-8010, p 9-10 Antenna Seal Valve MX-8156/BRA-18B.
- Operation: Requires a torus-type distendable membrane to conform to the BCA O.D. Will require an elastic material capable of up to 200% elongation (.50 → 1.00 in. capability for Goal 1) and up to 615% elongation (.65 → 4.0 in. capability for Requirements 9 → 11, and 14).
- Considerations: Elastic performance is directly related to whether reinforcing fabric is integral to the bladder membrane -- extremely difficult to achieve even 200% elongations with reinforcing. Non-reinforced bladder membranes -- pressure compensated, having a theoretical upper limit of 700 → 800% stretch.

  Self extrusion of the bladder along the cable axis must be prevented. As the Dia. material variance gets larger, sea pressure forces grow geometrically requiring that the exposed face of the bladder be minimized proportionately. Backup plates must therefore be provided, which are articulated and have sufficient strength to resist the differential pressure across the seal. Note - that if backup plates are not employed, the bladder membrane is "presumed" to have high longitudinal and radial stiffness -- implying at the very minimum, a reinforced fabric construction.

Elastic Stretch implies a proportional increase in imposed shear stress on the BCA across the seal. Heat Loads/Fatigue/Wear impact must be addressed.

Discussions with two different seal manufacturers - Seal Master Corp. and Presray (see attached) resulted in establishment of preliminary performance limit constraints of 20% for outward stretch and 1/8th on the diameter for inward inflation of a continuous I.D. periphery.

CONTACT REPORT

DATE 8/27/74

CID REPRESENTATIVE	PERSON CONTACTED: 8:45 AM	
W. R. Richards	Mr. McNeal	TELE. ☑
	(Sales manager)	VISIT ☐
SUBJECT Inflatable Seals	ORGANIZATION Seal Master Corp.	
	PHONE NUMBER 6-1-216-673-8410	

CONTACT REPORT:

173 Osceola Ave
Tallmadge, Ohio
44278

1. Ration of no to 2:1 -- inflated outward & ratios of 1/8th on the diameter -- inflated inward due to buckling @ the I.D. periphery.
2. Single ply construction, 50 PSID, Two-ply 60→80 PSID. 200 PSID current capability w/ 400 PSID a development possibility
3. Typ. config: 1.50" ID; 3.50" OD (deflated) to 5.00" O.D. inflated X 2→2.50" Long. This is not an off-the-Shelf item: $1200 est Setup; $350→450 prototype part est. cost and Delivery est @ 3 mos.
4. Hydraulic actuation recommended.
5. Seawater compatable

ACTION ITEMS	DISTRIBUTION
Preliminary spec. to be sent W/E Aug 31, w/ tel. con response NLT Sept 10.	F. Reitz R. Baltkila

NEXT CONTACT DATE _____

FORM NO. 900-009-0576

PRESRAY

PAWLING, NEW YORK 12564
(914) 855-1220

September 18, 1979

Gould Inc.
Chesapeake Instrument Div.
6711 Baymeadow Drive
Glen Burnie, MD 21061

Attention: Mr. Bill Richards
Department 630

Subject: Pneuma-Seal

Dear Mr. Richards:

Here is the current brochure on our inflatable seals and related custom designed rubber products. On pages 4 and 5 you will find the more readily available sections, however, as I indicated on the phone, none of these would be suitable for the small shaft seal which we discussed. Regardless, after reviewing the brochure, if you have any further ideas as to how we could be of assistance, please contact us again.

Thank you for your expression of interest.

Sincerely,

PRESRAY

Theodore C. Hollander, Jr.
Vice President

TCH:alv
enc: (1) S-76
cc: Adrian Lumelleau

THE PNEUMA-SEAL® PRINCIPLE

Fig. 1



Doors and other closures can be positively sealed by using PNEUMA-SEAL. The seal is inflated with air or other fluid by a pressure-regulated supply system (which can also be furnished by Presray). When pressurized, the seal conforms to uneven surfaces and provides an efficient, reliable barrier to dust, moisture, contaminants and/or pressure differential. Operating pressures are usually in the range of 5 to 100 P.S.I., depending on the PNEUMA-SEAL cross-section and application. Expansion capabilities, the ability to close a "gap" (Figure 1), vary from cross-section to cross-section. Large "gaps" may be accommodated but it should be noted that as the gap diminishes, the pressure required to seal against a given pressure differential is reduced and the flex life of the seal increases.

Five domestic patents issued. Others pending.

AVAILABLE IN MANY CONFIGURATIONS

PNEUMA-SEALS®, shown in a variety of cross-sections on pages 4 and 5, can be supplied as continuous loops (Fig. 2), in strip form with sealed ends (Fig. 3), in "U" or similar shapes with preformed corners (Fig. 4), in endless configurations with preformed corners (Fig. 5), or in complex configurations (Fig. 6). In many cases, a seal will conform to the corners or radii of a given installation without the necessity for preforming these corners or radii into the seal. Minimum bend radius information for circular seals, or corners on rectangular seals, is available. When requesting this data, refer to the desired cross-section (see pages 4 and 5) and the applicable plane of use as indicated (Fig. 7-9). Arrows indicate direction of inflation.

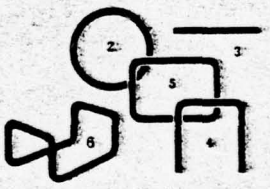


Fig. 7



Fig. 8

Fig. 9

PNEUMA-SEAL® CONSTRUCTION

Presray seals are available in four different types of construction.

A. Extruded with vulcanized joints or ends.

B. Extruded and either fully preformed or with preformed corners, with vulcanized joints or ends.

C. Fully molded, seamless (no vulcanized joints).

D. Fully molded, seamless (no vulcanized joints), reinforced with Nylon, Nomex, Glass or Dacron Fabric.

The extruded construction seals are offered for applications where economy is of primary concern. However, in applications involving high pressure and/or repeated, continuous use, where safety and reliability are of major importance, the molded fabric reinforced construction is recommended. The molding process eliminates any possibility of weak points at "spliced" joints. The fabric reinforcing gives additional structural integrity assuring better resistance to rupture and tear and provides superior flex life.

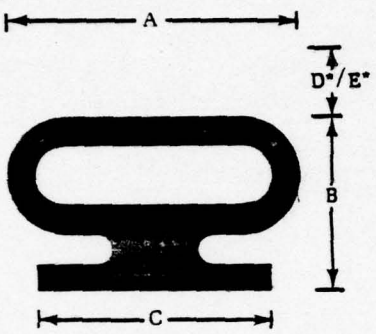
no joints!!!

Presray's unique facilities and processing techniques result in seamless (no vulcanized joints) rubber products of virtually limitless length and size to your specifications (fabric-reinforced or non-reinforced).

No longer do you have to contend with the loose tolerances normally associated with extruded rubber products.

standard pneuma-seal designs

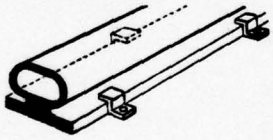
I.



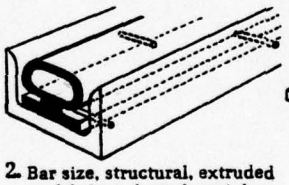
TYPE	MATERIAL	A	B	C	D*	E*
PRS 573	NEOPRENE	11/16	7/16	11/16	1/4	1/8
PRS 537	EPDM	1-1/4	5/8	1	3/8	1/4
PRS 543	SILICONE	1-1/4	5/8	1	1/4	NA
PRS 535	EPDM	2	7/8	1-3/4	3/4	3/8
PRS 552	SILICONE	2	7/8	1-3/4	1/2	NA
PRS 548	EPDM	3	1-1/4	2	1	1/2
PRS 580	VARIOUS ELASTOMERS FABRIC REINFORCED	1-1/4	5/8	1	3/8	1/4
PRS 582		2	7/8	1-3/4	3/4	1/2
PRS 583		3	1-1/4	2	1-1/4	3/4
PRS 584		4	1-1/8	3-1/4	2	1-1/4
PRS 705		4	1-5/8	3	1-3/4	1-1/4
PRS 590		7-1/4	2-1/16	4-1/8	3	2

*Recommended maximum gap: "D" for low pressure differentials; "E" for higher pressure differentials (Consult Presray).

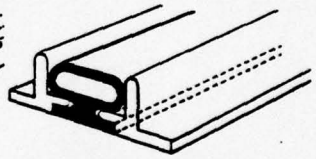
RETENTION SYSTEM:



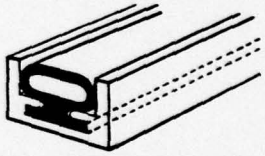
1. Passivated steel, stainless steel, or aluminum clips tack *welded or screwed* to a flat surface. Seal is "snaked" between clips.



2. Bar size, structural, extruded or fabricated steel, stainless steel, or aluminum channel, with rollpins pressed through holes drilled through the flanges. Seal is "snaked" between roll pins.

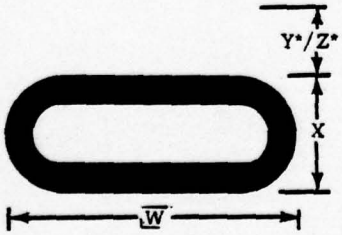


3. Extruded stainless steel or aluminum shapes – one permanently welded or screwed in place; one movable to facilitate seal installation.



4. Extruded aluminum retainer for strip seals. Seal is fed into retainer from one end.

II.

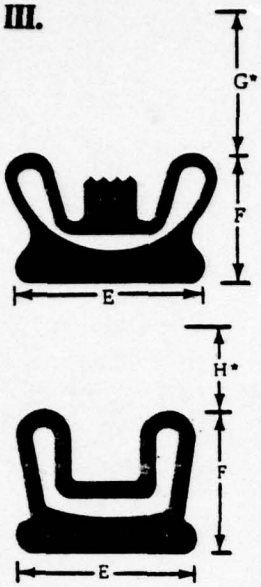


TYPE	MATERIAL	W	X	Y*	Z*
PRS 102	NEOPRENE	15/16	5/16	3/16	1/8
PRS 525	NEOPRENE	1-1/2	1/2	7/16	1/4
PRS 509	SILICONE	1-1/2	3/8	3/8	NA
PRS 423	NEOPRENE	2	1/2	3/4	3/8
PRS 520	NEOPRENE	3	3/4	1	1/2
PRS 701	VARIOUS ELASTOMERS FABRIC REINFORCED	1-1/4	3/8	3/8	1/4
PRS 702		2	1/2	3/4	1/2
PRS 703		3	3/4	1-1/4	3/4
PRS 706		4	1	1-3/4	1-1/4
PRS 512		6	1-1/2	2-1/2	1-3/4

*Recommended maximum gap "Y" for low pressure differentials; "Z" for higher pressure differentials (Consult Presray).

RETENTION: These seals are most suited to circular configurations for radial expansion inward or outward where the built-in tension is sufficient to hold them in place. If used in other configurations adhesives are required. Note, however, that adhesives are significantly less reliable than the mechanical retention systems used with Category I or III seals.

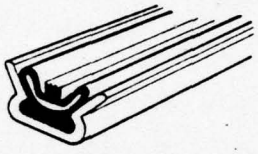
III.



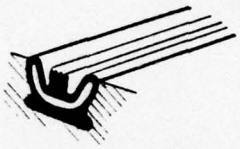
TYPE	MATERIAL	E	F	G*
PRS 591	VARIOUS ELASTOMERS FABRIC REINFORCED	11/16	1/2	7/16
PRS 595		7/8	1/2	3/8
PRS 581		7/8	5/8	1/2
PRS 594		1-3/4	1-7/32	1-7/32
PRS 599		5/8	1/2	3/8
		E	**F**	**H***
PRS 592		5/8	1/2	1/4
PRS 598		11/16	1/2	1/4
PRS 597		7/8	5/8	3/8
PRS 708		1-3/4	1-7/32	13/16

*Recommended Maximum Gap

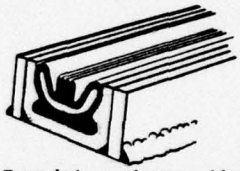
RETENTION SYSTEM:



5. Extruded Aluminum retainer (available from Presray). Seal "snaps" in place.



6. Machined groove (consult Presray for dimensions). Seal "snaps" in place.



7. Extruded synthetic rubber retainer (available from Presray) rigidly supported on sides. Seal "snaps" in place.

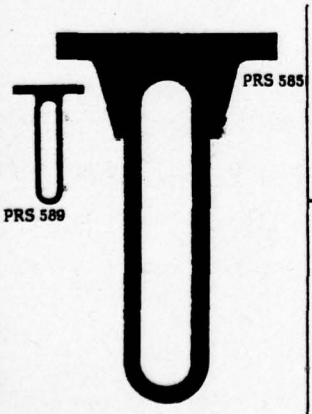
IV.



TYPE	MATERIAL	E	F	G*
PRS 704	VARIOUS ELASTOMERS FABRIC REINFORCED	17/32	7/16	3/8
PRS 707		21/32	7/16	1/2

*Recommended Maximum Gap

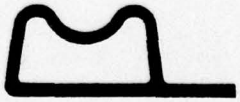
RETENTION SYSTEM: These seals are suited to circular configurations for radial expansion inward or outward where the built-in tension is sufficient to hold them in place. In other configurations they can be readily bonded into straight-sided machined or fabricated channel retainers.



SPECIAL RECTANGULAR SECTION WITH "SNAP IN" BASE.



PRS 533 INFLATABLE "P" SEAL.



VARIOUS SIZES OF INFLATABLE ROUND AND RECTANGLE TUBES AVAILABLE.



PRS 593 OVAL WITH "SNAP IN" BASE.



FITS 1", 2", 3", 4", 5" STANDARD CHANNELS.



PRS 135 COMBINATION INFLATABLE AND LIP SEAL.



PNEUMA-SEAL® MATERIALS

Presray seals are available in the basic elastomers tabulated below. Please note that the ratings given to the properties of the elastomers are based on Presray compounds as they are applied to inflatable seals. The ratings of other manufacturers may differ as a result of compounding variables and end product use. Also, note that the addition of fabric reinforcing overcomes drawbacks associated with poor tear resistance and elongation characteristics of silicone and nitrile seals.

1 Excellent
2 Good
3 Fair
4 Poor

	PRINCIPAL ADVANTAGES	TEAR RESISTANCE	ELONGATION	HIGH TEMPERATURE	LOW TEMPERATURE	OIL RESISTANCE	FUEL RESISTANCE	WEATHER RESISTANCE	OZONE RESISTANCE	RADIATION RESISTANCE	ACID RESISTANCE*	ALKALI RESISTANCE*	WATER RESISTANCE
EPDM	HEAT RESISTANCE TO 250°F WEATHER & AGING RESISTANCE	2	2	1	2	4	4	1	1	**	1	1	1
NEOPRENE	GENERAL PURPOSE OIL RESISTANCE	2	2	2	2	1	3	1	1		2	2	2
SILICONE	HIGH & LOW TEMPERATURE RESISTANCE	4	3	1	1	3	4	1	1		3	3	2
NBR (BUNA N, NITRILE)	OIL AND SOLVENT RESISTANCE	3	3	2	2	1	2	2	4		2	2	1

EPICHLOROHYDRIN, NATURAL RUBBER, VITON, POLYURETHANE, BUTYL ALSO AVAILABLE IN SOME CONFIGURATIONS.

*Ratings are to serve as a general guide only: information should be requested relative to specific chemicals involved.

**For Radiation Applications specify: Presray EPDM. Write for data sheets on radiation resistance of 40 Durometer EPDM Compound E401; 60 Durometer EPDM Compound E603.

PNEUMA-SEAL® STANDARD AIR CONNECTIONS



1/8" I.D. FLEXIBLE TUBE (NON-REINFORCED). SAME MATERIAL AS SEAL.

TYPE I:

TO BE USED WITH PRS 102, 509, 535, 537, 543 AND 573.

1/4" DIAMETER CLEARANCE HOLE REQUIRED. (BREAK EDGE OR COUNTERSINK).



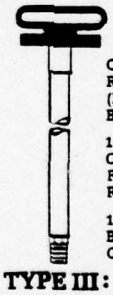
CRIMPED FERRULE (MATERIAL: BRASS).

3/16" I.D. REINFORCED HOSE.

TYPE II:

TO BE USED WITH PRS 580, 591, 592, 593, 598, 599, 701, 704 AND 707.

3/8" DIAMETER CLEARANCE HOLE REQUIRED.



CRIMPED FERRULE .48" O.D. (MATERIAL: BRASS).

1/4" I.D. x .47" O.D. HOSE FABRIC REINFORCED.

1/8"-27 NPT BRASS CONNECTOR.

TYPE III:

TO BE USED WITH PRS 512, 581, 582, 583, 584, 594, 595, 597, 702, 703, 705 AND 706.

1/2" DIAMETER CLEARANCE HOLE REQUIRED.



BRASS.

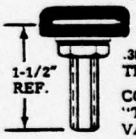
1/8"-27 NPT STRAIGHT THREAD.

1/8"-27 NPT TAPERED THREAD.

TYPE IV:

TO BE USED WITH PRS 423,520,525,535 AND 548.

7/16" DIAMETER CLEARANCE HOLE WITH 15/16" DIAMETER x 5/16" DEEP COUNTERBORE FOR NUT AND WASHER, OR 15/16" DIAMETER CLEARANCE FOR ENTIRE ASSEMBLY.



.302-32 THREAD.

CONTAINS "TIRE" VALVE CORE (MATERIAL: BRASS OR NICKEL PLATED BRASS).

TYPE V:

FOR SEALS REQUIRING AUTOMOTIVE TYPE VALVE CORES.

5/16" DIAMETER CLEARANCE HOLE WITH 5/8" DIAMETER x 7/32" DEEP COUNTERBORE FOR NUT AND WASHER, OR 5/8" DIAMETER CLEARANCE FOR ENTIRE ASSEMBLY.

END CONNECTIONS

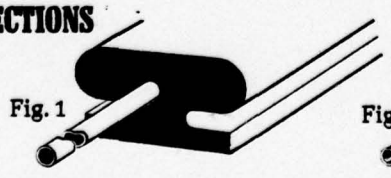


Fig. 1

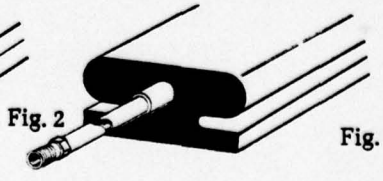


Fig. 2

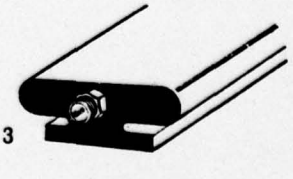


Fig. 3

Type I, II and III air connections can be located in the ends of applicable sections, as illustrated above. Threaded pipe connections, as illustrated in Fig. 3 above, can also be furnished molded in place.

APPENDIX R

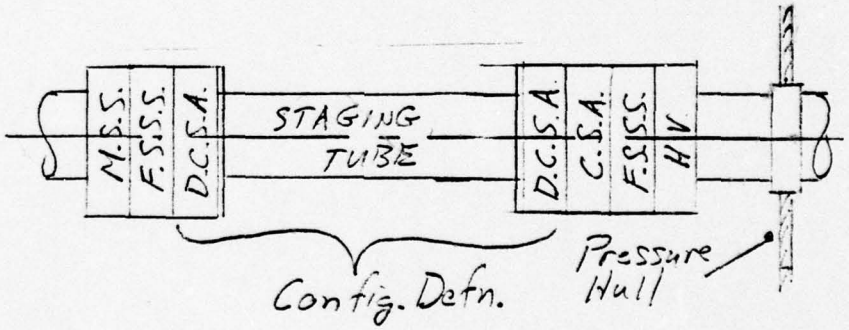
APPENDIX R

DYNAMIC SEAL, FIXED, 2 POSITION, SPLIT

APPENDIX R

DYNAMIC SEAL, FIXED, 2 POSN, SPLIT

- Configuration: Split clamp, guillotine actuated with viscous fluid seal. Ref. DRSS Proposal, p 3-46, Para. 3.6.2.2, Figure 3-28. Pressure Compensated.
- Operation: Sequenced operation to open. No capability exists to prevent seawater inrush while opening -- or, to adequately seal around a 4" OD Antenna Element.
- Considerations: Tandem operation is mandatory, with a Staging Tube an integral necessity. One of the seals must always be engaged about the 0.65 Dia. i.e.,



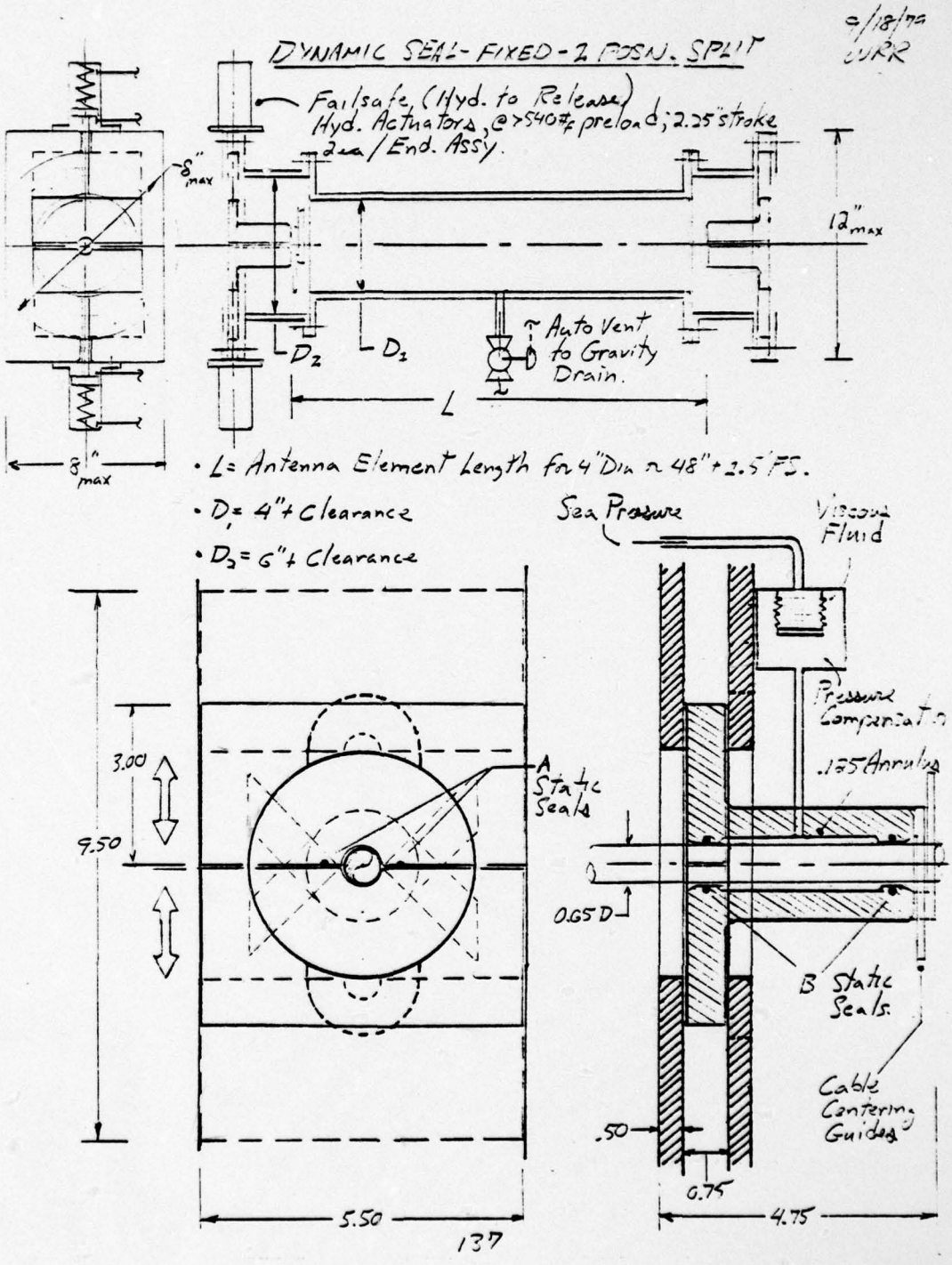
Any Antenna Element brought thru the pressure hull must be pressure equalized across the differential area (difference of the B.C.A. vs. the Ant. Elem.), in order to eliminate the force difference generated by ambient sea pressure forces, i.e.,

	Cable Dia.	A_{cs}, in.^{2}	Pressure Spectrum Force Difference @ 180 PSID, $\#_f$	@ 600 PSID, $\#_f$	@ 1000 PSID, $\#_f$
Req. 14	.65	.332	60	200	332
	1.00	.785	82	273	853
	1.25	1.227	161	549	895
	1.38	1.495	209	-	1,163
	1.50	1.766	258	-	1,434
	1.75	2.404	373	-	2,072
	2.00	3.142	506	-	2,810
	2.50	4.906	823	-	4,574
	3.00	7.065	1,212	-	6,733
Req. 11	4.00	12.560	2,205	-	12,228
	6.00	28.260	5,086	-	28,260

CHETSA experience with respect to Guide Tube ID vs. Cable OD sizing indicates that "push a rope" phenomenon becomes increasingly significant as the Guide Tube ID gets >150% of the cable OD.

Without the Staging Tube, one of the evaluated Transfer Mechanisms, Appendix C, becomes a Very High Risk development item due to the Pinch Roller preload requirement. CHETSA experience indicates a 3X thrust capability over prelaod values. Max preload employed to date is 22#. A 2 >2.50 Cable Dia. would require a 10X increase in torsional preload of articulated rollers, and this appears to be an upper limit-simply based upon torsional mt. envelope requirements -- and in addition, the higher preload impact on the Antenna Element itself would have to be resolved.

Per NUSC C-SA32-235, 7 Nov 73, Para. 3.2.2.11 Longitudinal Stiffness of an 8.5 in. long 0.65 Dia. BCA/279, 6.5" unsupported shall be <0.150" @ 80# axial compression.


DYNAMIC SEAL - FIXED - 2 POSN. SPLIT
Failsafe (Hyd. to Release) Hyd. Actuators @ >540#f preload; 2.25" stroke 2ea/End. Assy.
δ" max
12" max
D2
D1
Auto Vent to Gravity Drain.
L
8" max
• L = Antenna Element Length for 4" Dia ≈ 48" ± 2.5" FS.
• D1 = 4" + Clearance
• D2 = 6" + Clearance
Sea Pressure
Viscous Fluid
Pressure Compensator
.125 Annulus
3.00
9.50
A Static Seals
0.65 D
B Static Seals
Cable Centering Guides
.50
0.75
5.50
4.75
137

At 3.25" unsupported length, per Appendix G, estimated axial compression capability equals $320\#_f$. This is probably the limiting load capability due to guide/support sizing constraints for placement of a cable support (articulated) mechanism immediately inboard of the dynamic seal.

Within the staging tube, articulated constraints must be employed to assure that cable buckling is prevented as it passes thru the outboard dynamic seal. They would be analogous to forming an annulus only marginally larger than that of the cable, i.e., approximately .75 in. ID_{max} and approximately 4.25 in. ID_{max} for the Antenna Elements.

	Vol In.)^3	Wt,$\#_f$
(1) Vol./Wt. Est:		
• Staging Tube		
Rd. Mech. Tubing 5½ OD x .50 wall	1425	134
& 26.7#/ft x ≈ 5.0' lg		
• End. Seal Adapter Tubes (2 ea)		
Rd. Mech. Tubing 8" OD x .50 wall	502	40
@ 40.1#/ft x ≈ .5' lg		
• Split Clamp Assys. 8" x 12" x 1.75 thk (X2)	336	102
- Split Seal @ (5.50 x 6.0 x .75) +		22
(2" OD x 3.5") x 2 = 36 in.^{3} x 2		
• Support Flgs @ (11" OD x 5/8" thk - 4" OD	206	62
x 5/8" thk) x 4 = 82.42 in.^{2} x 3/8 thk x 4		
• 4 ea. Hyd. Cyl. Actuators est @	100	80
1 → 1.50 Bore x 2" Stroke + 6" Dim. $Adj._{max}$		
i.e., est 2" OD_{max} x 8"		
	2,569	440

∴ Assume Vol @ 1.5 → 1.65 ft^3

& Assume Wt @ 440 → 550$\#_f$

NOTE -- This weight assumes a 5000 psi burst resistance. Config. location could possibly permit reduction of wall thickness to .38 or even .25 in.

(2) An Est. Cost for a Completed Assy - (Hardware Fab.) is $2 → 4k.

(3) The Staging Tube Config. w/End Seal Adapters could also support the Dynamic Seal - Variable Diameter Options.

APPENDIX S

APPENDIX S

DYNAMIC SEAL, VARIABLE, IRIS

APPENDIX S

DYNAMIC SEAL, VARIABLE, IRIS

1. Overlapping Plates w/Ant. Elem. Dia. Hole, punched out.
2. Increase plate width to 3". Length to 3½" w/same hole location in from actuator end.
3. Questions: How do we seal the labyrinth?

   Do we need to? - - - - yes!
4. (a) Plate Dimension = f(Max Hole Dia)

   i.e. -- Length $\approx$ 2.5 X (characteristic Dim., Closed Assy")

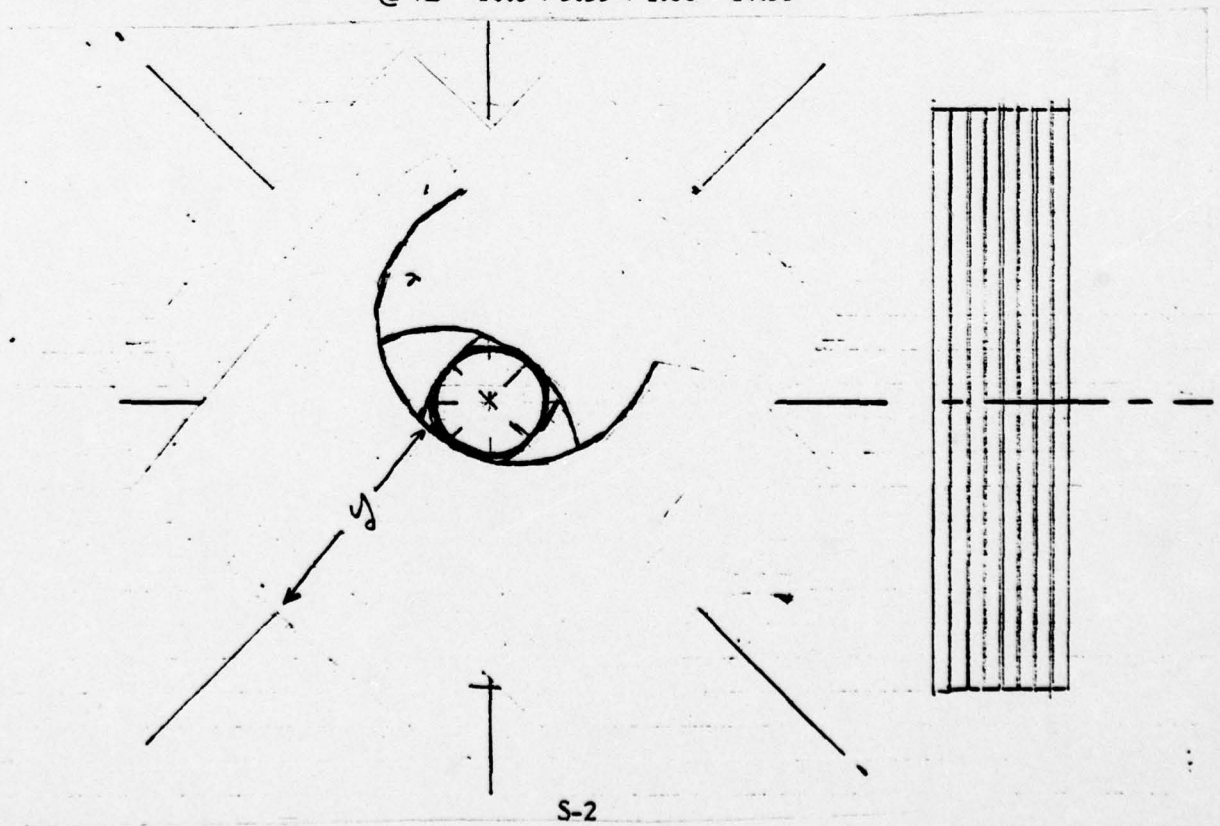
   Width $\approx$ 2.2 X $\rightarrow$ $2.5X_{max}$

   $Y_{est} = 1X_{min} \rightarrow 1.25X_{max}$

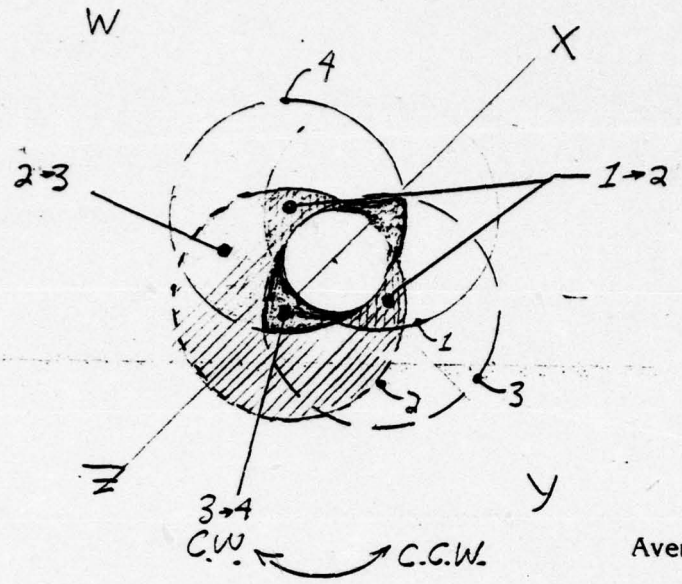
   (b) Est OD_{max} 2.5X + (X-.65) + .25X Factor-of-Safety

   of "open" array lens elements @ 1 3/8D = 3.45 + .65 + .34 = 4.44"

   @ 4D = 10.0 + 3.35 + 1.00 = 14.35"



Lens 1-2, 3-4



Comments

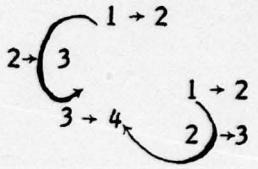
(a) 1 → 2 establishes 1st orifice level

i Top Slit Area$_w$ ≈ 7/16" x 3/32"

ii Bottom Slit Area ≈ 7/16"x3/32"

(b) 2 → 3 establishes 2nd orifice level

Pattern as follows:



Average Orifice 7/16" x 3/32" = .0836 in.^{2}

Mean Free Path, est =

3/16" + 3/16" + 3/16" + 7/16 + 7/16" ≈ 1.5"

1 → 2, 2 → 3, 3 → 4, 2 → 3, 2 → 3

$\left(\begin{matrix}\text{Plt}\\ \text{thk}\end{matrix}\right)$

(1) (a) Calculation of Est. Leakage @ 180 Psid; .44" X .19" = .084 in^2

∴ From Orifice Chart, Appendix N, Est Leakage = 28 GPM!! X 2 (two paths).

(b) If Lens Plt. Thickness = 3/64"; Orifice Area ≈ .0418 in.^{2}

∴ From Orifice Chart, Est Leakage = 14 GPM!! X 2

(c) In order to reduce to an "Acceptable Value", of 2.1 GPM -- we need an area of 003 in.^{2}

∴ $\frac{.003\ \text{in}^2}{.44\ \text{in. slit length}} = .0068"$

This is in the range of SHIM STOCK!

(2) Modified Mean Free Path - 4 element Iris Lens =

$.0068" + .0068" + .0068+ + 7/16 + 7/16 \approx .90"$

$\therefore$ 8 element Iris $\approx$ 1.80"

16 element Iris $\approx$ 3.60"

32 element Iris $\approx$ 7.20"

(3) Cal. of Water Flow Vel.:

$$V = \frac{2.16 \text{ GPM} \times 231 \text{ in}^3/\text{Gal}}{.003 \text{ in}^2 \text{ orifice area} \times 2}$$

$= 166320"/\text{min}$

$= 231'/\text{sec}!$

(4) (a) Cal. of Est. Δ Psi/element*

$$\text{Psi/ft} = \frac{4.352 \times 10^{-6}}{d_{Hyd}^4} \times \rho \times Q,\text{GPM} \times \nu \text{ cs}$$

where $\rho = 62.4\#_{m/ft^3}$

$Q = 2.16$ GPM

$\nu = 1.01 @ 68^{\circ}F$

$d_{Hyd} = 1/16"$

$= 45.26 \text{ psi/ft} \times \frac{.44" \text{ path length}}{12"/\text{ft}}$

or 1.66 psid/element

or -- We would need > 108 iris elements for 180 Psid.

*Laminar Flow Approximation as we must get very low flow. Trial Assumption Only!

(b) Check by analogy: Pipe Flow Calculator, Mears-Industrial/Scientific Ltd.

.003" A_{cs} actual vs .049" A_{cs} analogy (.25 bore) ; where $Q = f(D^2 P/L)$

For 5' Length @ 180 PSID = 580 GPH

For 1' Length @ 180 PSID = 2900 GPH

For .75' Length @ 180 PSID = 3867 GPH

(c) i.e. -- 267 X Less, ≈ 14.46 GPH @ 7.5" for .003" A_{cs} actual

∴ Est Flow @ Δ Psid = 180, 7.5" Total Path Length = .241 GPM

This is approximately equivalent to a 32 element Iris Lens Assy.

(5) Conclusion:

Configuration requirements indicate that a 32 element Iris Lens Assy is the minimum required. Assume 64 elements as worst case for 600 Psid capability. Assuming that orientations are every 45°, indicating 8 ea. ganged elements driven by a single actuator, w/8 ea. actuators. A single actuator mech. may be possible by employment of the Brampton Engr. Bubble Stabilizer articulation concept sizing, using their Model #8.75, indicates a 12" OD x 3/4" thk for 1 3/8D lumps and a Model F20, indicates 27" OD x 1 3/8" thk for 4 lumps!

(6) Recommendations:

- 8 ea. independent actuators should be considered from the standpoint of minimizing the excessive OD reqts for 4" Lumps — Potential reduction to 14.34" + 2 (2" act. thk) = 18.34" from 27.0".
- Element packaging @ .005" thk + .0018" clearance gap indicates a seal thickness of 64 x .0008 or .435"
- Optimize the Fluid Flow Analogy by more rigorous treatment + test certification.

BRAMPTON ENGINEERING

Plastics processing machinery □ Designers, manufacturers and consultants

August 23, 1979

Mr. F.M. Reitz,
Mgr. Mech. Eng.,
Gould Inc. Chesapeake Instr.,
6711 Bay Meadow Dr.,
Glen Burnie, MD 21061
U.S.A.

Gentlemen:

Further to your request we are pleased to submit our quotation for the following:

To supply a Brampton Engineering iris bubble stabilizer complete with stainless steel shutter blades housed in a machined cast aluminum housing, manually adjustable, without mounting brackets.

MODEL	RANGE	O.D.	PRICE
8.75	.375 to 8.75"	12"	$ 600.
20	5.5 to 20	27"	$2000.
30	10 to 30	38"	$2500.
40	20 to 40	51"	$3500.
50	35 to 50	59"	$4500.
70	48 to 70	84"	$6500.
85	65 to 85	96"	$8500.

The above prices are in U.S. funds, any applicable U.S. import duty included and prepaid, FOB Brampton (Toronto), Ontario. Terms: 1/3 down, balance 30 days. Delivery: 10 - 12 weeks from receipt of purchase order and down payment.

Thank you for this opportunity to quote and we will look forward to working with you on this project.

Yours very truly,

BRAMPTON ENGINEERING COMPANY LIMITED

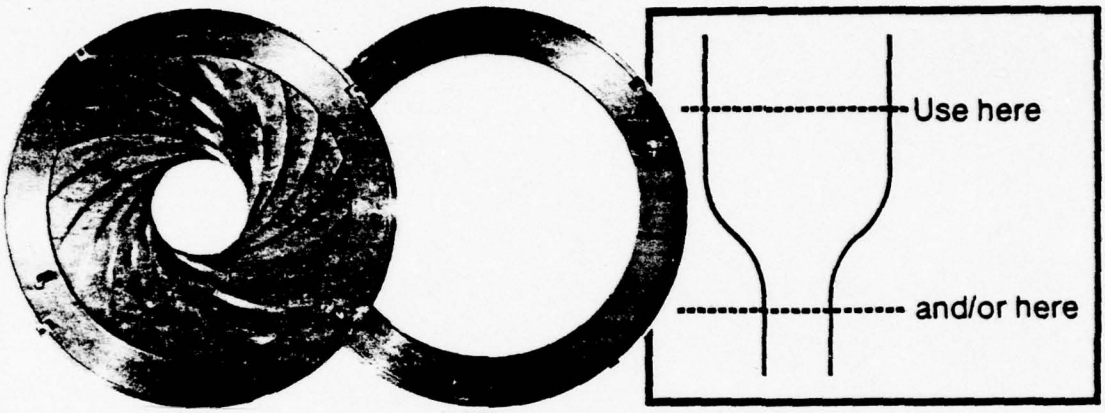
Don McHardy

Don McHardy,
Sales Manager

DMc/js

8031 DIXIE ROAD, BRAMPTON, ONTARIO, CANADA L6T 3V1 TEL: (416) 457-8323 TELEX: 06-97855

for blown film Bubble Stabilizers



Bubble Stabilizers from Brampton Engineering increase blown-film line productivity by improving bubble stability and cooling, especially when processing UHMW/HDPE film.

The Bubble Stabilizer is an iris/diaphragm unit consisting of thin overlapping stainless-steel plates mounted within a heavy cast-aluminum ring. The diameter is infinitely variable by simple manual adjustment.

The unit can be used at or above the frost line and/or at the neck. Seven sizes are available for bubble diameters from 3/8" to 85".

Features

- Keeps bubble concentric and dead center between die and nips
- Helps stabilize bubble by reducing turbulence from air ring
- Increases bubble cooling and promotes level frost line by deflecting hot air away from bubble
- Aids uniform gauge control

For more information, please call or write:

Brampton Engineering,
8031 Dixie Road, Brampton
(Toronto), Ontario L6T 3V1.
Tel: (416) 457-8323. Telex: 06-96555

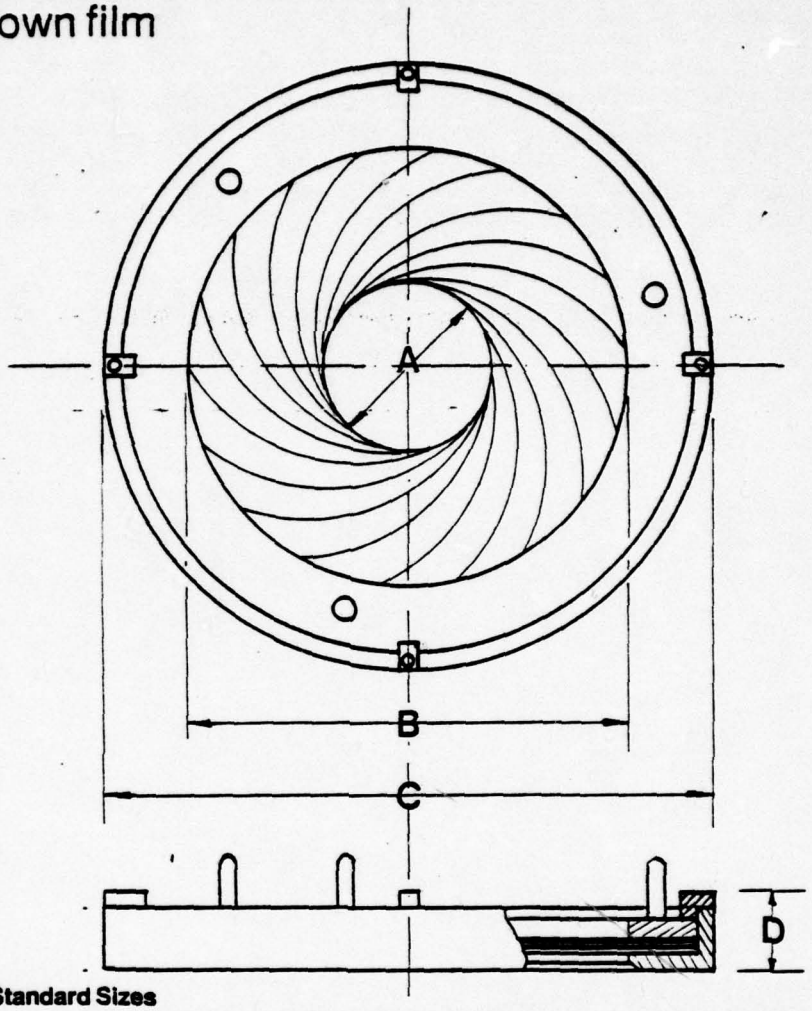
BRAMPTON ENGINEERING

Plastics processing machinery □ Designers, manufacturers and consultants

Atlanta (404) 536-8555 Boston (617) 281-3325 Detroit (313) 341-2500

Bubble Stabilizers

for blown film



Standard Sizes

Model	Bubble diameter		Outside diameter of unit	Thickness of unit
	A (Min)	B (Max.)	C	D
8.75	3/8	8 3/4	11 3/4	3/4
20	8	20	27	1 3/8
30	10	30	39	1 3/8
40	20	40	51	1 3/8
50	35	50	64	1 5/8
70	48	70	80	1 5/8
85	65	85	96	1 5/8

All dimensions in inches

For more information, please call or write:
Brampton Engineering, 8031 Dixie Road, Brampton (Toronto), Ontario L6T 3V1. Tel: (416) 457-8323. Telex: 06-96555

BRAMPTON ENGINEERING

Plastics processing machinery □ Designers, manufacturers and consultants

Atlanta (404) 536-8555 Boston (617) 281-3325 Detroit (313) 341-2500

Printed in Canada

APPENDIX T

APPENDIX T

HARDWARE/MANUFACTURERS BROCHURES

APPENDIX T

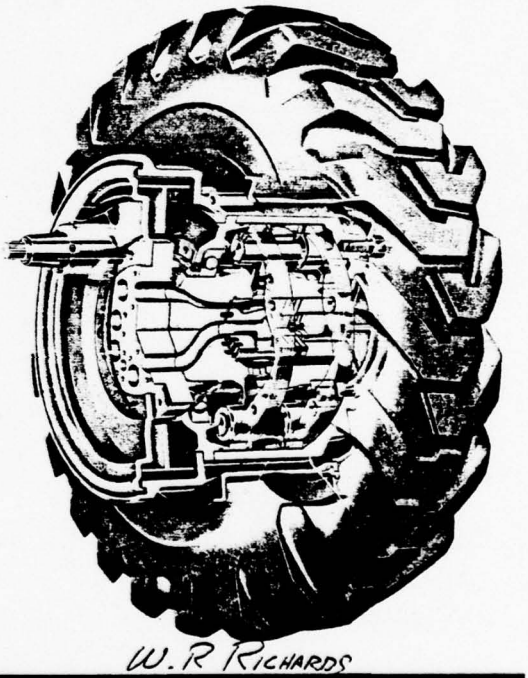
MANUFACTURERS BROCHURES

TABLE OF CONTENTS

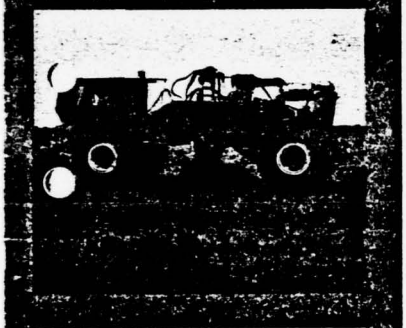
		Page
1.	Hagglunds-Hydraulic Wheel Hub Motors 0555 & 3160	T-3
2.	Quotation	T-10
3.	MIL-P-17869A Qualification	T-12
4.	SAMM-Hydraulic Motors M18-80 & M40-630	T-14
5.	HPI - MCV-ISO System	T-18
6.	PMI Motors - Introducing Torque Ring™	T-30
7.	Worchester Controls - Miser Ball Valves 3" to 8"	T-34
8.	Worchester Controls - Ti-Miser™ Ball Valves	T-40
9.	Worchester Controls - The Series 45 Ball Valve	T-46
10.	Lord Kinematics - Tube Form Mountings and Dynaflex ® Joints	T-52
11.	Lord Kinematics - Center Bonded Joints	T-63
12.	Warner Electric - Ball Bearing Screw	T-65
13.	Norco Inc., - Ball Reverser	T-68
14.	Lebus International, Inc. - Lebus™ Spooling System	T-80
15.	Sealol, Inc. - Sealol Design Guide	T-86
16.	Kamatics Corp. - Karon Bearings	T-90

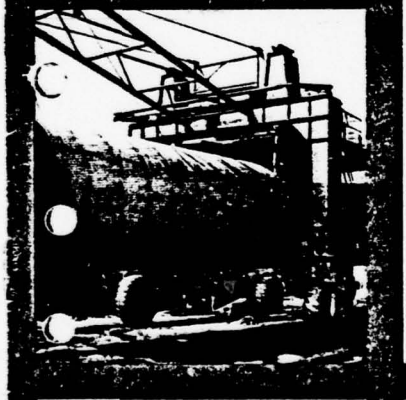
HÄGGLUNDS

HYDRAULIC WHEEL HUB MOTORS

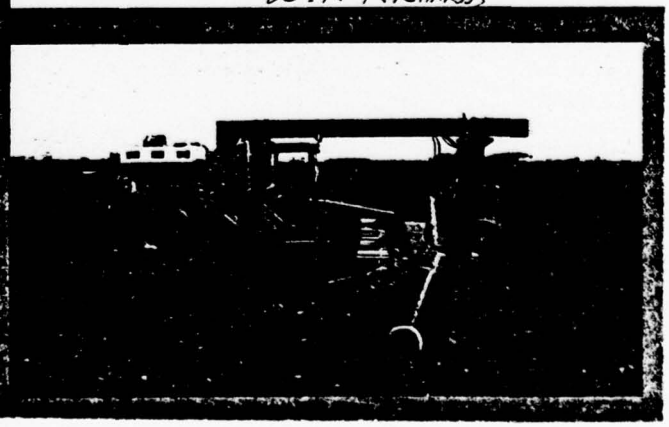


W. R RICHARDS







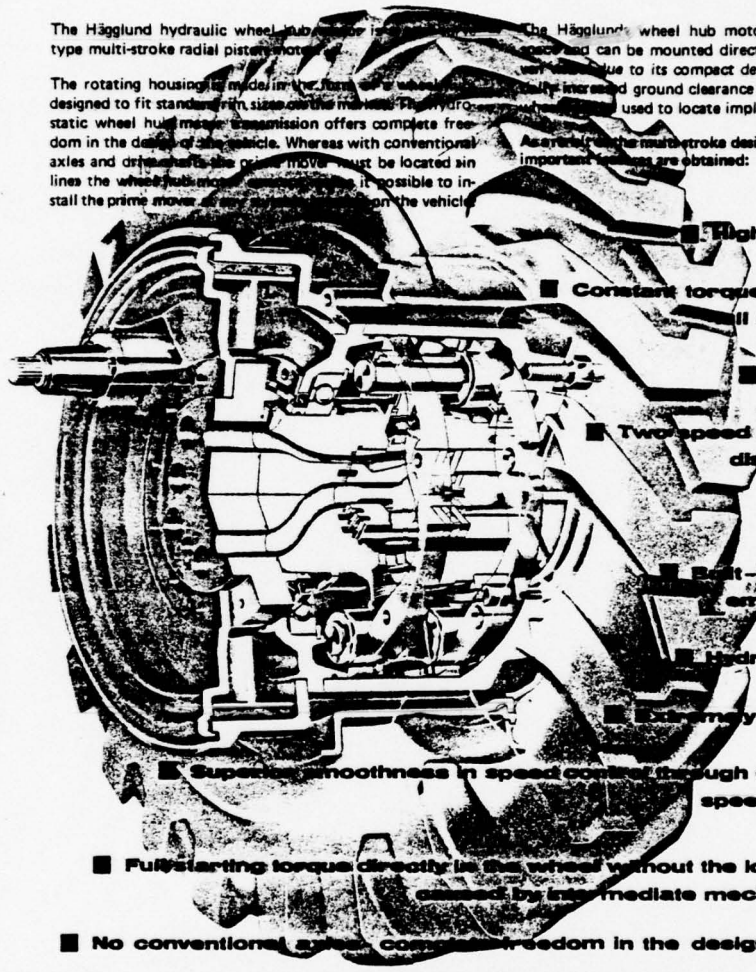


The Hägglund hydraulic wheel hub motor is a [illegible] type multi-stroke radial piston motor.

The rotating housing is made in the form of a wheel hub designed to fit standard rim sizes on the market. The hydrostatic wheel hub motor transmission offers complete freedom in the design of the vehicle. Whereas with conventional axles and drive shafts the prime mover must be located in line with the wheel hubs, [illegible] it possible to install the prime mover [illegible] on the vehicle.

The Hägglund wheel hub motor requires a minimum of space and can be mounted directly into the rim of the driven wheel due to its compact design. The result is substantially increased ground clearance and the space between the wheels can be used to locate implements etc.

As a result of the multi-stroke design principle, the following important features are obtained:



- High external loads
- Constant torque throughout the full 360° of rotation
- Free-wheeling
- Two speed ranges through displacement shift
- Reversible
- Built-on parking and emergency brake
- Hydrostatic braking
- Extremely low noise level
- Superior smoothness in speed control through outstanding low speed performance
- Full starting torque directly at the wheel without the loss in efficiency caused by intermediate mechanical gearing
- No conventional axles, complete freedom in the design of the vehicle

INTRODUCTION

TECHNICAL DATA

Motor type	FULL DISPLACEMENT				Max. peak pressure	Weight kg		Moment of inertia	
	Displacement V_i		Ideal torque m_v	Max speed n	p	without brake	with brake		
	lit/rev	in³/rev	Nm/bar	rev/min	bar			kgm2	lbf·ft·s2
0355	0,43	26,2	6,8	300	350	93	111	0,83	0,60
0555	0,57	34,7	9,1	400	350	98	116	0,83	0,60
1155	0,85	52,0	13,6	300	350	98	116	0,83	0,60
3460	1,70	103,5	27,0	200	350	280	355	4,54	3,28
3160	3,40 ★	207,0 ★	54,0 ★	200	350	290	365	4,54	3,28

★ In half displacement: Displacement – 1,7 lit/rev (104 in³/rev); Ideal torque – 27 Nm/bar

CONVERSION FACTORS

1 lit	=	0,220 Imp. gall.
1 lit	=	0,264 US gall
10 Nm	=	1,020 kpm
10 Nm	=	7,376 lbf·ft
1 bar	=	14,504 psi
1 bar	=	1,020 at
1 at	=	1 kp/cm²
1 kg	=	2,205 lbs

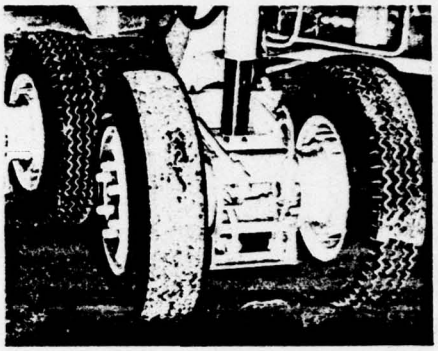
External loads on the motor must be kept within certain limits in order to ensure trouble-free operation. We assume an estimated equivalent maximum radial load F_R:

$$F_R = F_{Rstat}\ (1 + \alpha) + k \cdot r \cdot F_a$$

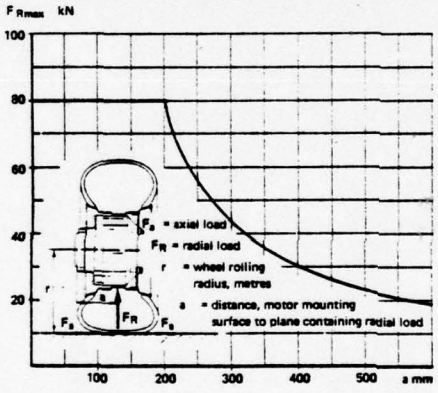
F_R is composed of two forces: one purely radial consisting of the static load plus a dynamic contribution represented by the »shock factor« α and one radial force consisting of the purely axial load multiplied by the »thrust factor« k and the wheel radius, r.

For motor Type 0355, 0555 and 1155 the »thrust factor« is 5.7 and for Type 3160 and 3460 it is 4.0.

The resultant equivalent radial load, must be contained within the limits given by the Diagrams below.

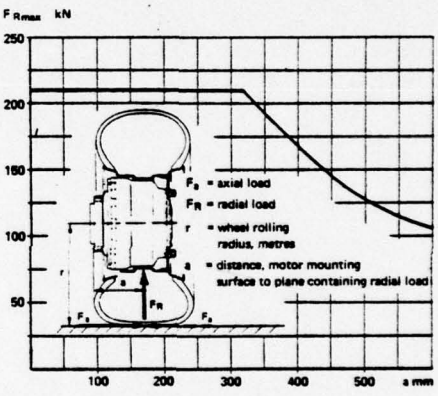


0355 0555 1155



Max. permissible F_a = 30 kN

3460 3160



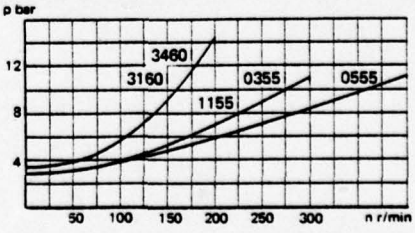
Max. permissible F_a = 75 kN

EXTERNAL LOADS FEED PRESSURE

The feed pressure requirements are shown in the diagram. Feed pressure is required to provide adequate control pressure for the pump and sufficient pressure in the low pressure line of the closed loop circuit to maintain continuous positive contact between the cam and the cam follower bearings.

The fluid supplied to the closed loop circuit by the feed pump shall be filtered by a 10 micron nominal rated filter.

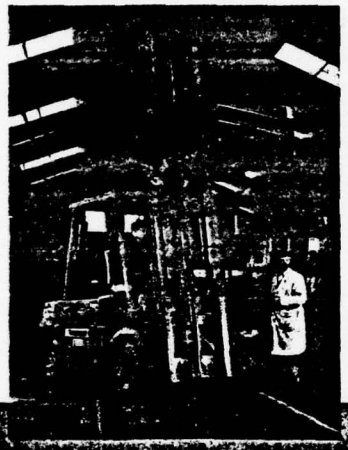
The motor case pressure must not exceed 3 bars.

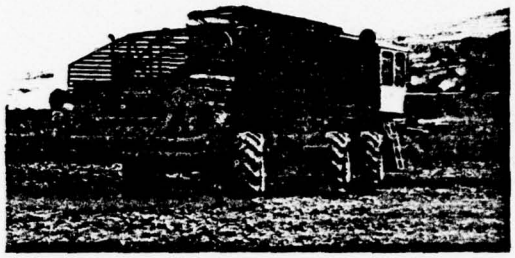


Manoeuverability

The high mechanical efficiency of the Hägglund wheel hub motor in combination with the control simplicity of the hydrostatic drive system offers extremely good manoeuverability.

For fork lift trucks it is very important, that the drive and speed control is simple and easy to handle, so that the driver can concentrate on the load handling.





Free space between the wheels

For many types of vehicles the possibility of utilizing the free space between the wheels for different types of implements is an important requirement. One typical example is agricultural vehicles of different types.

Hägglunds wheel hub motors are installed directly into the rims of the driven wheels, thus providing a free space between the wheels.

For other types of vehicles, e.g. mining vehicles, the height of the machine must be limited. In this case the free space between the wheels can be utilized for accomodation of the prime mover. This way extremely low vehicles can be designed.



Low noise level

During the last few years regulations regarding maximum noise level have been introduced in many countries. Max. permissible noise levels will be further decreased in the near future.

The combustion engine with the built-on hydraulic pump can normally be loacted in such way, that it can be easily insulated. For the secondary part of the transmission the insulation is normally very complicated.

The high frequency hydraulic noises typical for the high-speed hydraulic units is not produced by the Hägglund wheel hub motors, that run at low speed. In addition, the typical noise from gear boxes, drive shafts and other transmission components is eliminated through the use of the wheel hub motors.

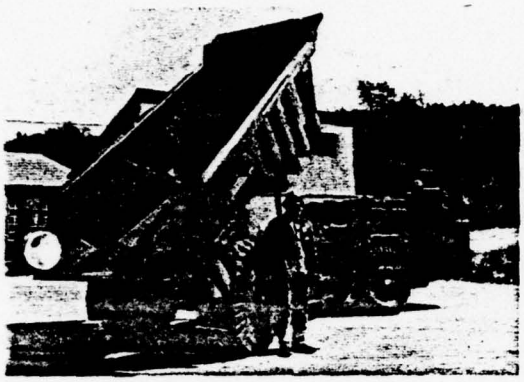
Also in comparison with a torque converter transmission the hydrostatic transmission offers advantages as far as low noise level is concerned. With the torque converter the diesel engine must run at very high rpm in order that the torque converter can transmit the full tractive effort. The hydrostatic transmission will produce full tractive effort also at a comparatively low diesel engine speed.



Driven and steered wheels with extremely large steering angles

BIG VEHICLES REQUIRE SMALL SPACE!

This somewhat contradictory statement has now become a reality through the use of hydraulic wheel hub motors. The lack of mechanical transmission components permits a steering angle of more than $\pm$ 90° for the driven and steered wheels. The moving platform, designed for transportation of payloads up to 200 tons, has a manoeuverability similar to a hovercraft.



Complete range of valves

Included in the Hägglund mobile line of equipment is a complete range of motor valves. By means of these valves the motors can be free-wheeled, which means that they rotate freely on their main bearings.

The valves can also be used for changing the displacement of the motors in ratio 1:2, thus providing two speed ranges for a given oil flow.

Through combination of the different valves a wide speed range can be obtained with a limited oil flow.

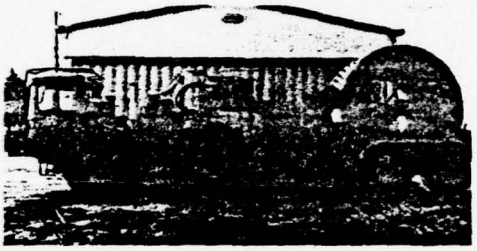
The four-wheel drive mining dumper has a hydraulic system based upon these valves, which ensures smooth and flexible speed control of the vehicle.

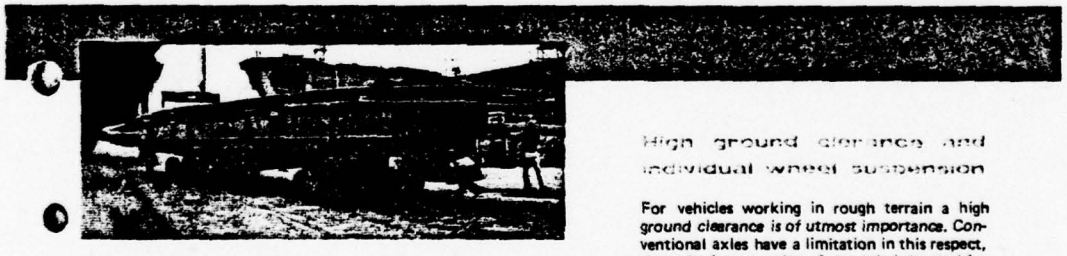
[illegible]

Auxiliary drives using wheel motors is an interesting application in vehicles operating both on-road and off-road. The photo below shows such a vehicle. Two wheel motors are installed in the front wheels of the cable laying trailer. When the vehicle is driven on-road the wheel motors are free-wheeled, which means, that they rotate freely on their main bearings similar to a conventional wheel on its bearings.

When driving off-road, the motors are engaged, which provides a supplementary tractive effort. Dis- and re-engagement of the motors is accomplished by means of a Hägglund valve mounted directly onto the connecting flange of the motor.

Also the drive rolls for the cable drum are driven by two wheel motors.





High external loads

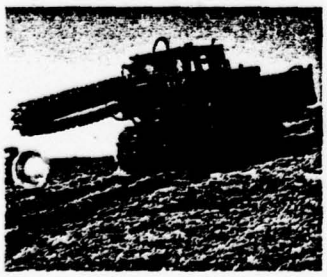
The rugged design of the Hägglund motor with the heavy duty main bearings completely hydraulically balanced permits an external loading capacity equivalent to the toughest heavy duty tyres on the market.

High ground clearance and individual wheel suspension

For vehicles working in rough terrain a high ground clearance is of utmost importance. Conventional axles have a limitation in this respect, since the lowest point of the axle is located far below the wheel centre. The use of wheel motors eliminates the axles, which increases the ground clearance substantially.

Up to now heavy off-road vehicles have not been equipped with wheel suspension. Individual wheel drive by means of wheel hub motors eliminates the need of axles and drive shafts, which permits separate suspension of each wheel, for instance on a pivoting arm. Experience from test vehicles has shown, that this makes driving much more comfortable for the operator and also that the speed in rough terrain can be increased considerably.





High output horse-power

The output corner horse-power of the motor is very high. The trencher, also called the »Roc-saw», has a 1000 Hp diesel engine installed for two 3160 wheel hub motors, that drive the chain. The average horse power output is only slightly lower than the max. horse power output.

The Hägglund wheel motors are designed to operate on conventional petroleum base hydraulic oil. Normal oils for combustion engines can also be used. In that case we recommend oil type 10W30. Excessive operating temperatures sharply reduce the service life of oil and rubber seals.

The temperature should be kept below 60°C (140 F), if at all possible, since the rate of oxidation of the oil increases rapidly above this temperature.

The hydraulic oil can be chosen in consultation with an oil supplier and should meet the following requirements:

Recommended viscosity at operating temperature min 20 cSt.

Min. permissible viscosity 10 cSt.

Max. continuous operating temperature 70°C (158 F).

Max. permissible operating temperature 85°C (185 F).

The oil should contain anti-wear additives.

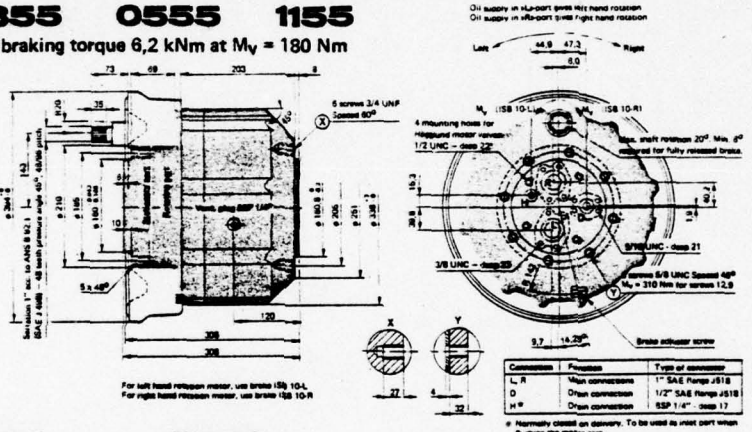
Whenever in doubt contact Hägglunds or the local Hägglund representative.

OIL RECOMMENDATIONS

DIMENSIONS

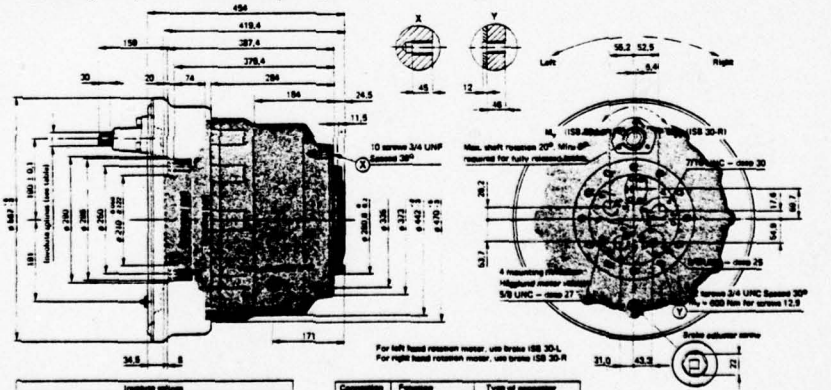
0355 0555 1155

Max. braking torque 6,2 kNm at M_V = 180 Nm



3160 3460

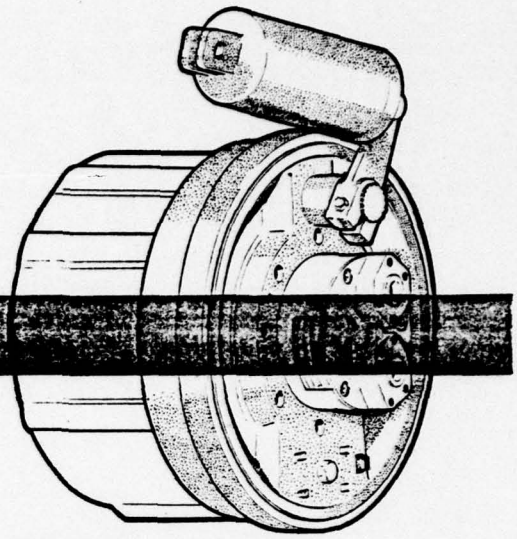
Max. braking torque 20 kNm at M_V = 630 Nm



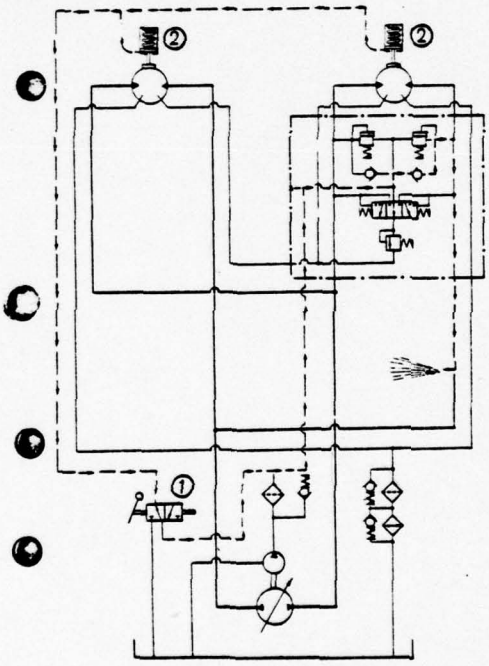
BRAKE SYSTEM

The braking ability inherent in the hydrostatic transmission is normally sufficient for dynamic braking. In addition a parking and emergency brake system is required.

The Hägglund brake system, consisting of a machanically operated internal shoe brake, brake lever and spring-on hydraulic cylinder, provides a reliable parking and emergency brake system.



ACCESSORIES

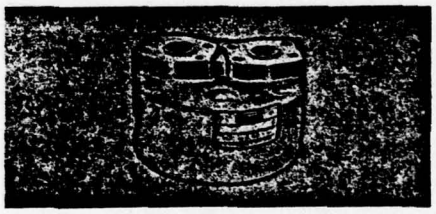


The function of the braking system is shown in the circuit above. The brake is operated by the charge pressure via the brake operating valve pos 1 and the hydraulic cylinders pos 2. When the vehicle is parked, the cylinders are drained through the brake operating valve to tank and the brake is actuated. In case a hose in the main line should burst, the automatic emergency brake comes on. When the hose bursts, the charge pressure drops, the brake cylinder is drained and the brake comes on automatically, irrespective of whether the operator actuates the brake operating valve or not. Although the brake system is mainly intended as a parking and emergency brake system, it can also be used for dynamic braking if required.

VALVES

The introduction of the Hägglund complete line of wheel motor valves has substantially simplified the layout of hydrostatic wheel motor transmissions. The valves that mount directly on to the wheel motors provide all necessary functions for a mobile transmission system. By locating the valves directly on to the motors, all line mounted valves have been eliminated and the number of pipe couplings reduced to a minimum.

For detail information on the valves refer to our separate brochures and application manual.



WHEEL BOLTS

For the mounting of the rim on the wheel motor Hägglunds provide wheel bolts in different configurations, that will fit most of the standard rims on the market.



QUOTATION

T. H. PARIS, INC.

Hydraulic and Pneumatic Systems and Components

Trenton: (609) 882-6550 TELEX 84-3310
Telephones: WATS: N. J. (800) 792-8810 • Pa., Del., Md., Conn. (800) 257-7901

180 EWINGVILLE ROAD • P. O. BOX 5061 • TRENTON, NEW JERSEY 08638

TO: Gould Inc.
Chesapeake Inst. Div.
6711 Baymeadow Drive
Glen Burnie, Md. 21061

ATTN: Mr. William Richards

SUBJ.: Hagglunds Motors

DATE: July 23, 1979

QUOTE NO.: 79Q8599

JOB NO.: C2508 602317

YOUR INQUIRY NO.: Verbal

ITEM	QUANTITY	DESCRIPTION	UNIT PRICE	NET AMOUNT
		Note: For OEM Discounts see end of Quote		
1		Hagglunds Hydraulic Motor, Model #2150	$5,334.00	
		OEM DISCOUNT		
		Quantity — Discount		
		1-2 — NET		
		3-4 — Less 3%		
		5-9 — Less 5%		
		10-24 — Less 10%		
2		Hagglunds Hydraulic Wheel Motor Model #3160	5,480.00	
		Quantity — Discount		
		1-4 — Less 40%		
		5-9 — Less 40-10%		

TERMS: Net 30 Days

DELIVERY: Stock/12 Weeks aro

PAGE: 1 of 2

F. O. B. Shipping Points

This quotation subject to conditions printed on reverse side. We especially call your attention to paragraph 2 relating to our Warranty and Limitations of Liability.

Respectfully submitted,
T. H. PARIS, INC.

By: Charles W. Lewis

Charles W. Lewis gk

QUOTATION

TO: Gould Inc.

ATTN: Mr. William Richards

SUBJ.: Hagglunds Motors

DATE: July 23, 1979

QUOTE NO.: 79Q8599

JOB NO.: C2508 602317

PAGE: 2 of 2

ITEM	QUAN.	DESCRIPTION	UNIT PRICE	AMOUNT
		Quantity & Discount continued Quantity — Discount 10-24 — Less 40-15% 25-49 — Less 40-20% Prices in effect at time of shipment will apply.		

T. H. PARIS, INC.

HÄGGLUNDS
High torque Hydraulics

TECHNICAL BULLETIN

71.05.25 | 5

Re.: Hägglunds high-torque hydraulic motors in US Navy test

Hägglunds hydraulic motors have been tested at Hägglunds hydraulic laboratory in a US Navy testprogram according to specification MIL-P-17869 A.

The motor has been fully approved by US Navy authority. The test did include e.g. the following performance:

- The motor have been operating at a diff. -pressure of 4 500 psi and maximum speed during 15 minutes.
- A number of starts have been made with a motor- and oil temperature of -17° C (0° F)
- Complete mechanical and volumetric efficiency tests.
- Test of the slow speed capacity.
- Continuous operation at a differens pressure of 3000 psi during 100 hours.
- Inpact shock test.

Örnsköldsvik, Sweden, May 25th 1971
AB Hägglund & Söner
Hydraulics Division

Bo Södersten
Chief Engineer

Enclosure: Testcertificate

NAVAL SHIP ENGINEERING CENTER
CENTER BUILDING
PRINCE GEORGES CENTER
HYATTSVILLE, MARYLAND 20782

IN REPLY REFER TO
6164:ARK:emm
4123/17869
Ser 258-6164.01

19 APR 197
Recv.....

(13 APR 1971)

A.B. Hagglund and Sonar
S-891 01 Ornskoldsvik, Sweden

Gentlemen:

Review of your Laboratory Test Report TR-24.11-70 indicates that your hydraulic motors meet the performance requirement of MIL-P-17869A.

Qualification approval is granted for hydraulic motors listed below subject to conditions printed on the reverse side of this page. Your products will be listed on Qualified Products List QPL-17869 as follows:

Government Designation	Manufacturer's Designation	Test or Qualification Reference		Manufacturer's Name and Address
		Performance	Shock	
CLASS II	Hagglund Motor Models: 2150, 2165, 4050, 4060 4070, 6170, 6185, 8285, 8385 for 3000 psig max. pressure	A.B. Hagglund and Soner, Rpt. TR 24.11-70 of 24 Nov. 1970	General Electric Co. Rpt. 70MW27 16 Dec 1970	Bird-Johnson Co. Fluid Power Division 883 Main Street Walpole, MA 02081 (Distributor) A.B. Hagglund & Soner S-891 01 Ornskoldsvik, Sweden (Manufacturer)

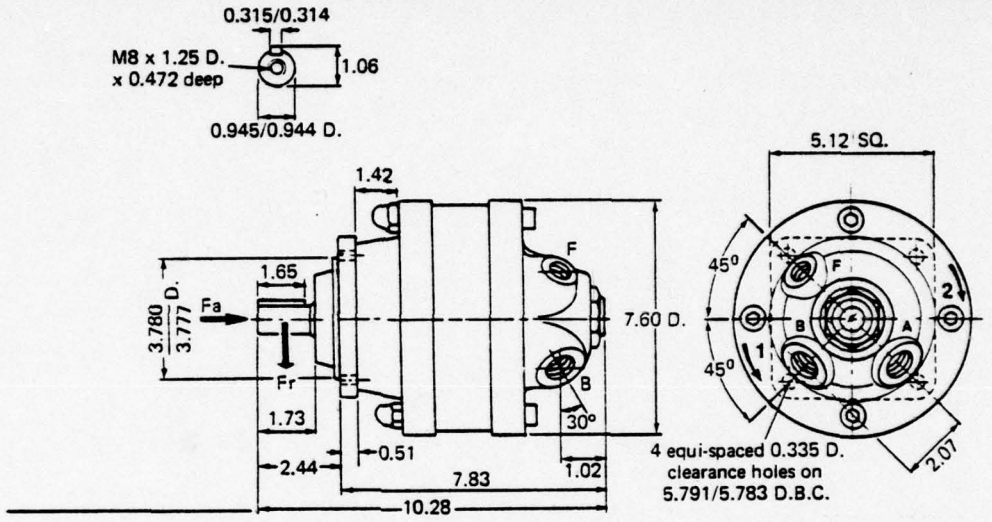
Sincerely yours,

Jean L. Harman

Copy to:
Bird Johnson Co.
883 Main Street
Walpole, Mass. 02081

Bird Johnson Co.
2022 Columbia Road, N.W.
Washington, DC 20009

J... ...
Head...
DCD S... ...Section
D... ...
Ship Sy... ...Engineering & Design Department
By direction of Commander
Naval Ship Engineering Center



DESIGN FEATURES

- Actual displacement/rev. . . . . 4.94 in^3
- Inertia of moving parts . . . . . 34.20 in^2 lbs.
- Continuous pressure rating . . . . . 2100 p.s.i.
- Max. intermittant pressure . . . . . 3000 p.s.i.
- *Theoretical torque/unit pressure . . 0.064 lbs. ft/p.s.i.*
- Max. speed . . . . . 750 r.p.m.
- Min. speed . . . . . 5 r.p.m.*
- Continuous max. input power. . . . . 16.5 HP
- Weight . . . . . 30.5 lbs.
- Radial load Fr. (no axial load) . . . . . 465 lbs.
- Axial load Fa (no radial load) . . . . . 350 lbs.

(See performance curves on reverse side.)

Note: This motor operates with free pistons. Proper charge pressure is required in all operating modes.

*For lower speeds, consult Bird-Johnson Company.

PORT CONNECTIONS

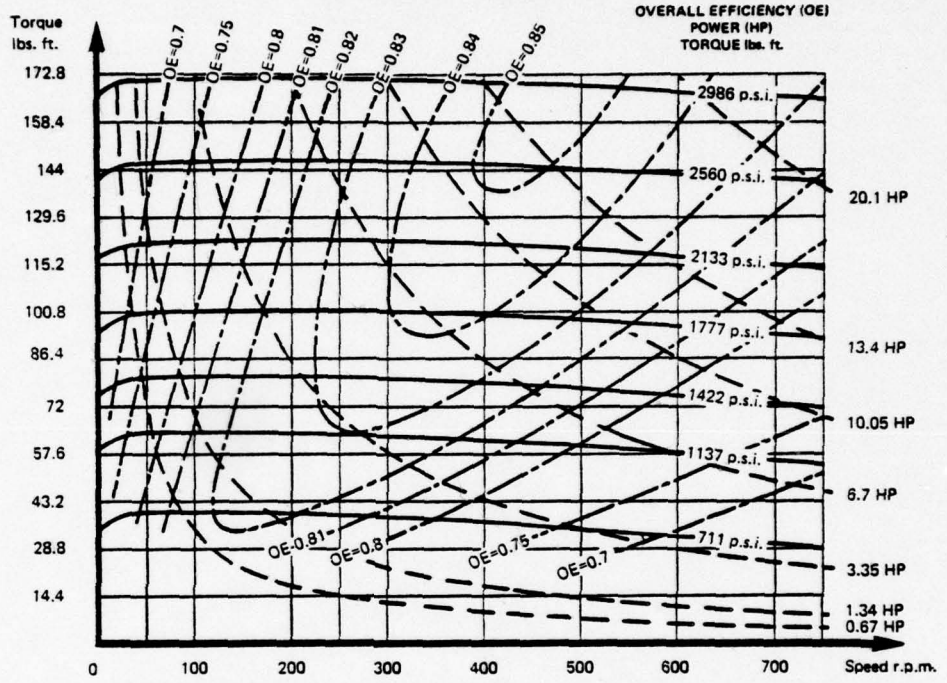
- Rotation is in direction 1 when pressure is connected to port A and return to port B.
- Rotation is in direction 2 when pressure is connected to port B and return to port A.
- Drain line (F) should always be connected directly to tank. Case should always be filled with oil.

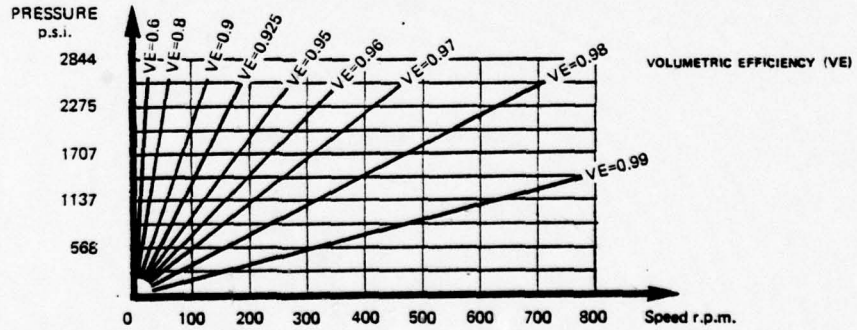
RECOMMENDED FLUID:

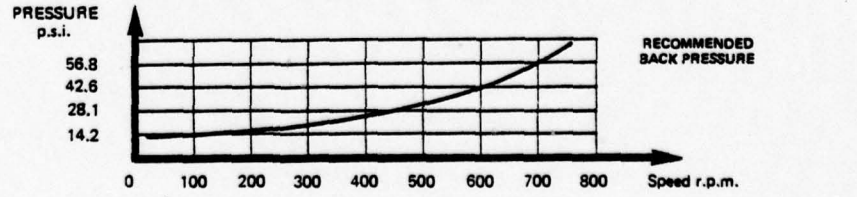
- Mineral oil with viscosity of 22 to 30 centistokes at 122°F.

S.A.E. PORTS	
A, B } 1 1/16" – 12 U.N.F. F 1/2" – 20 U.N.F.	1S-M-18-80-TO-1

PERFORMANCE CURVES
MODEL M-18-80



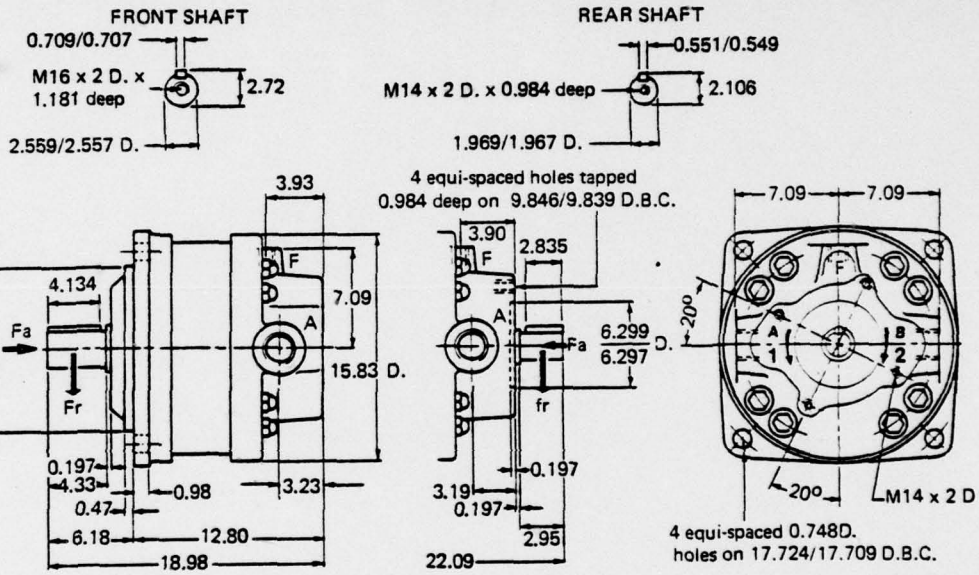




REVISED 1/76

BIRD-JOHNSON COMPANY
FLUID POWER DIVISION
110 NORFOLK ST. · WALPOLE, MASS. 02081 · (617) 668-9610

HYDRAULIC MOTOR
SERIES MODEL M-40-630



DESIGN FEATURES

- Actual displacement/rev. . . . . 39.78 in³
- Inertia of moving parts . . . . . 2941 in² lbs
- Continuous pressure rating . . . . . 3600 p.s.i.
- Max. intermittant pressure . . . . . 4600 p.s.i.
- Theoretical torque/unit pressure . . . . .517 lb-ft/p.s.i.
- Max. speed . . . . . 400 r.p.m.
- Min. speed . . . . . 0.5 r.p.m.*
- Continuous max. input power. . . . . 122 HP
- Weight . . . . . 313 lbs
- Radial load Fa (no axial load) . . . . . 5292 lbs
- Radial load fr (no axial load) . . . . . 1764 lbs
- Axial load Fa . . . . . consult us

(See performance curves on reverse side.)

Note: This motor operates with free pistons. Proper charge pressure is required in all operating modes.

*For lower speeds, consult Bird-Johnson Company.

PORT CONNECTIONS

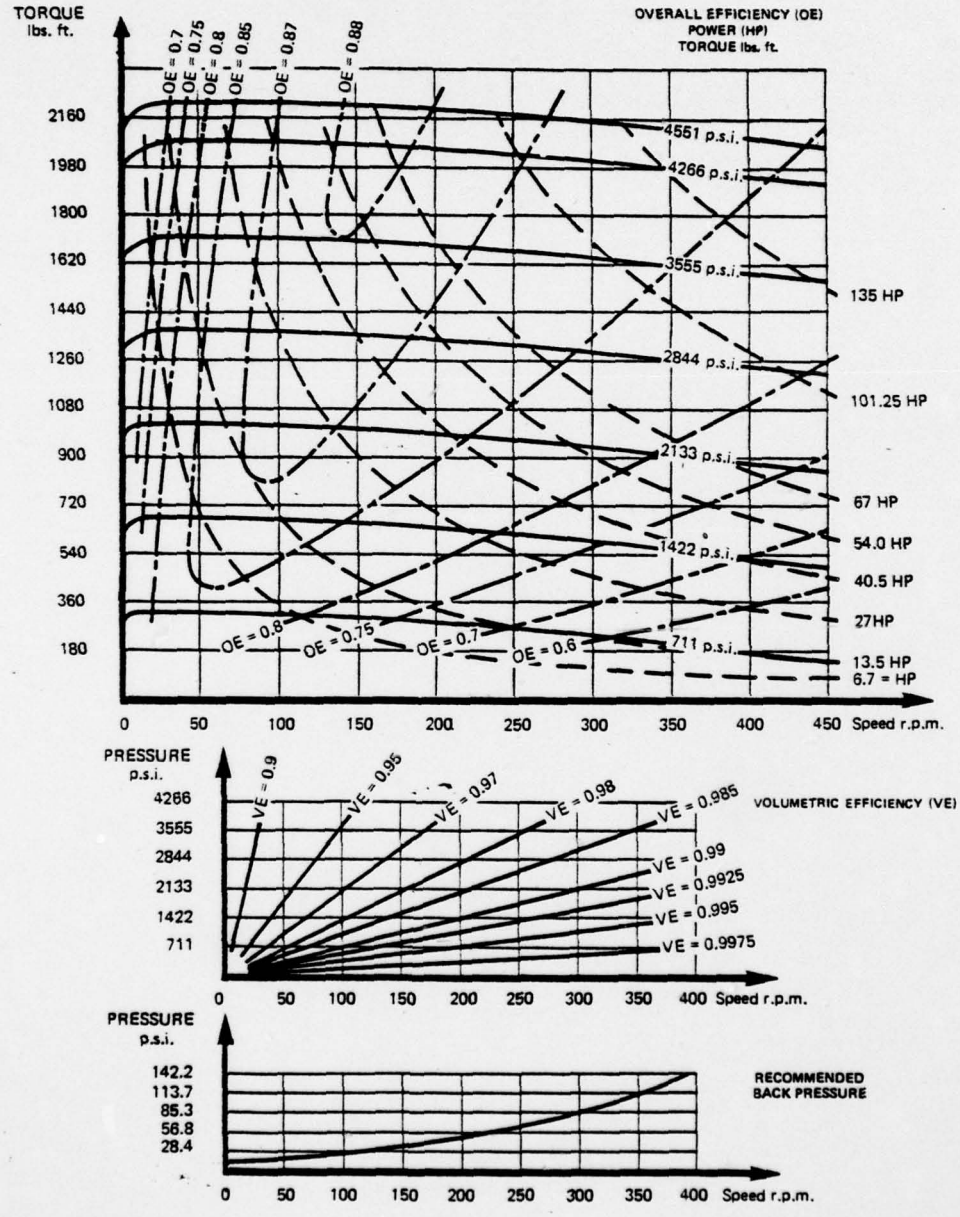
- Rotation is in direction 1 when pressure is connected to port A and return to port B.
- Rotation is in direction 2 when pressure is connected to port B and return to port A.
- Drain line (F) should always be connected directly to tank. Case should always be filled with oil.

RECOMMENDED FLUID:

- Mineral oil with viscosity of 22 to 30 centistokes at 122°F.
- Maximum case pressure – 14 p.s.i.

S.A.E. PORTS	2S-M-40-630-TO-1
A, B } 1 7/8"–12 U.N.F.	2S-M-40-630-TT-1 optional rear shaft
F 7/8"–14 U.N.F.	

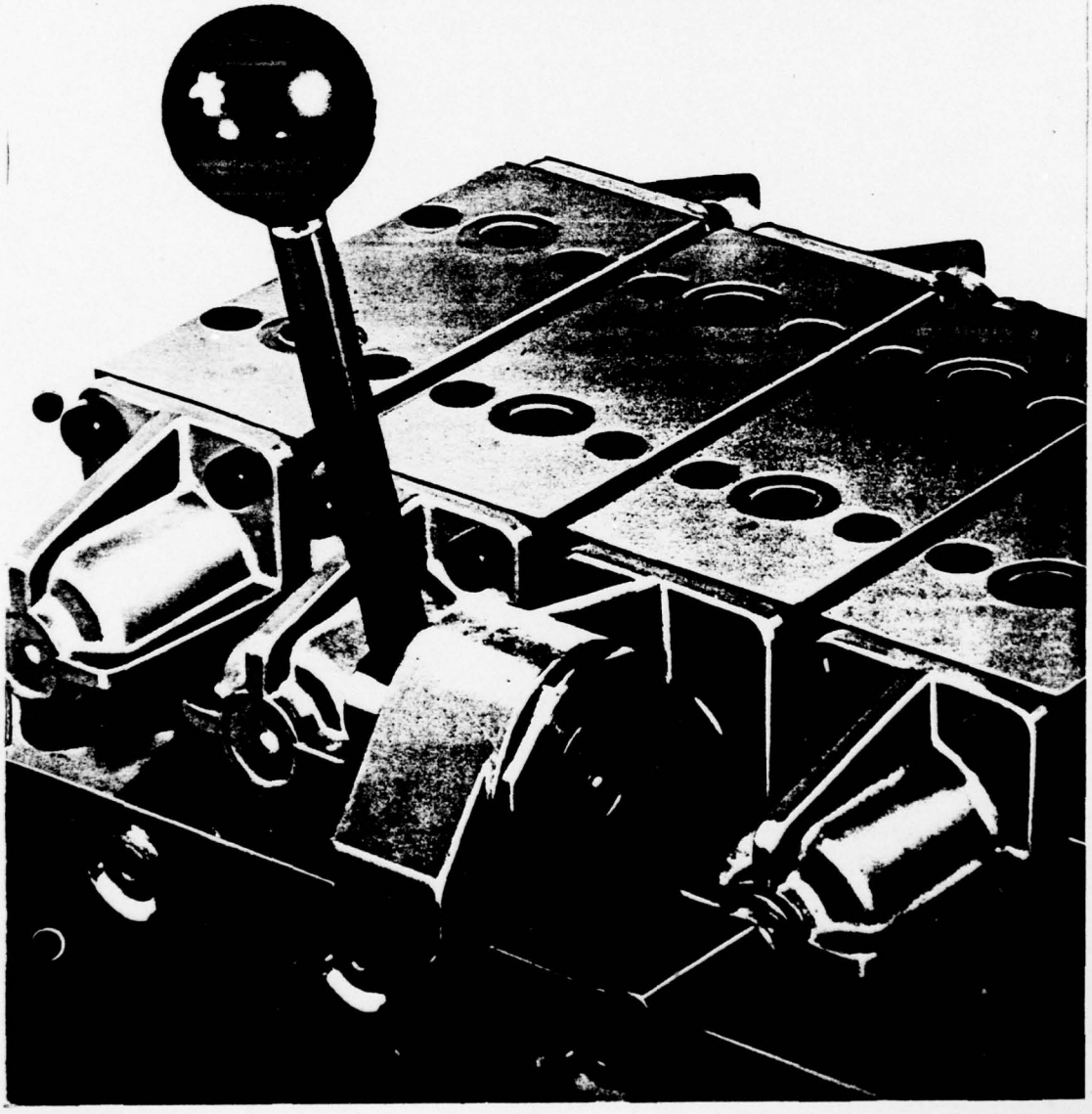
PERFORMANCE CURVES
MODEL M-40-630



REVISED 7/76

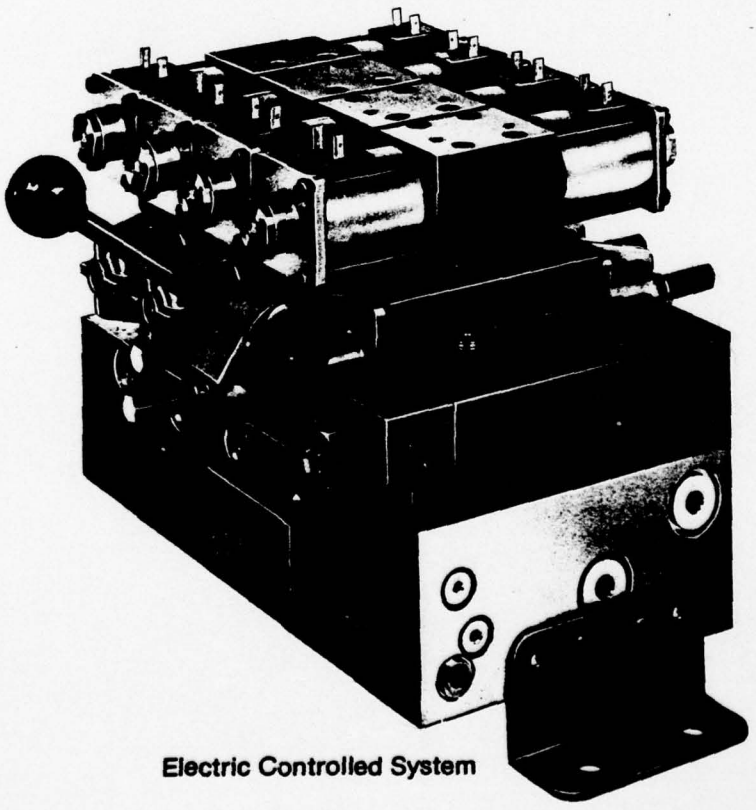
MCV-ISO SYSTEMS

T. H. PARIS, INC.
180 EWINGVILLE ROAD
P.O. BOX 5061
TRENTON, NEW JERSEY 08638
Trenton 609-882-6550 — New Jersey 800-792-8810
PA - DE - MD - CT 800-257-7901



MCV-ISO MANIFOLD FEATURES

For Electric, Remote Hydraulic and Manual Valve Systems



Electric Controlled System

PRESSURE COMPENSATION PER 4-WAY

Permits INDEPENDENT SIMULTANEOUS OPERATION (ISO) of multiple functions, regardless of load variations.

PROPORTIONAL FLOW CONTROL

VARIABLE BY:

- D. C. electrical signal
- Remote hydraulic pressure
- Manual handle position

PRECISE METERING

Controls movement from creep to full speed.

SYSTEM ADAPTABILITY

Can be used effectively with fixed displacement, variable volume pressure compensated, or load sensing pumps.

INTERNAL PILOT SUPPLY

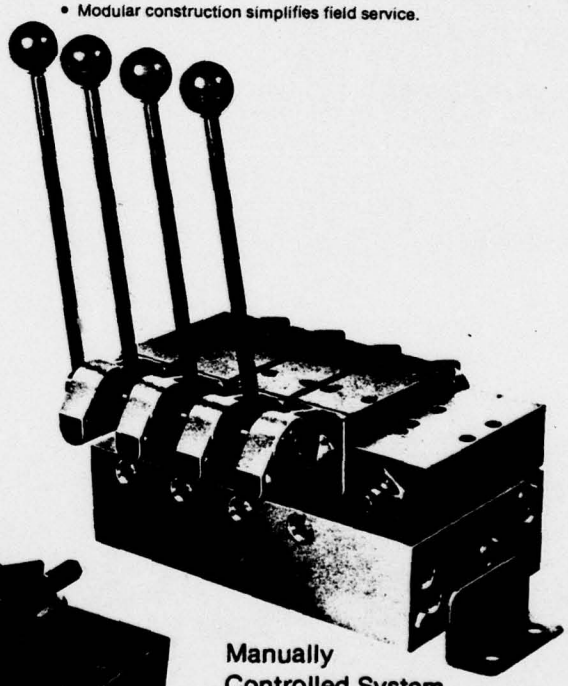
- No need for external pilot supply with electrically controlled system.
- Internal pilot system requires only a few cubic inches of oil per function.

NO SPECIAL FILTRATION REQUIRED

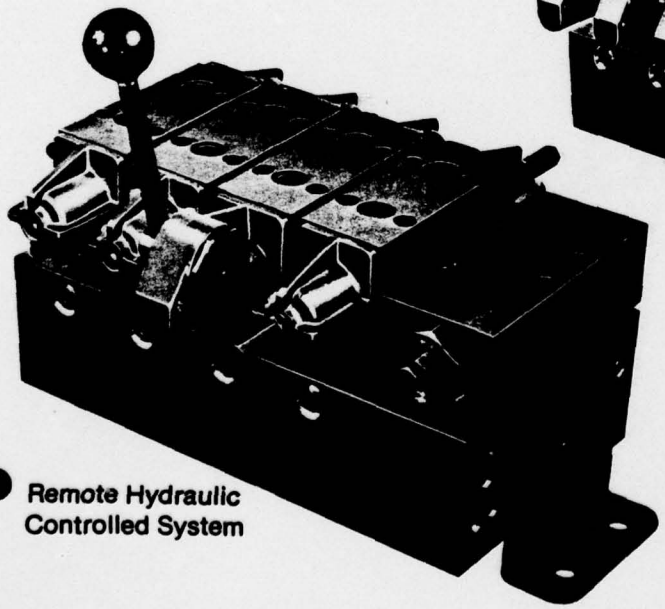
- No built-in pilot filters.
- 25 micron return line filtration acceptable.

REDUCES COSTS

- The manifold reduces space requirement and the amount of plumbing.
- *Built-in CDM compensators eliminate the need for* external pressure compensated flow controls, pressure reducing valves, flow dividers, etc.
- Unloading valve has built-in relief for fixed displacement pump systems.
- Compensation per 4-way can eliminate multiple pumps and transfer box.
- Modular construction simplifies field service.



Manually Controlled System



Remote Hydraulic Controlled System

3

MCV-ISO SYSTEMS

MCV-ISO SYSTEM WITH PRESSURE COMPENSATED PUMP

The pressure reducing and flow regulating CDM compensator (C) is used for each individual directional control valve (A) in the MCV-ISO manifold. It meters fluid to the valve (A) maintaining a constant pressure drop across the 4-way spool, equal to the pressure established by the bias spring (B) Once the flow requirement of the orifice created by the shifted 4-way spool (A) is satisfied, the compensator (C) will modulate to maintain a constant flow to the load. The compensators are used in parallel assuring independent control simultaneously, to any number of functions, provided the total flow demand does not exceed the available supply. When used with a pressure compensated pump, this is the only type of compensator required.

A. Adjustable Orifice Created by Shifted 4-way Spool.

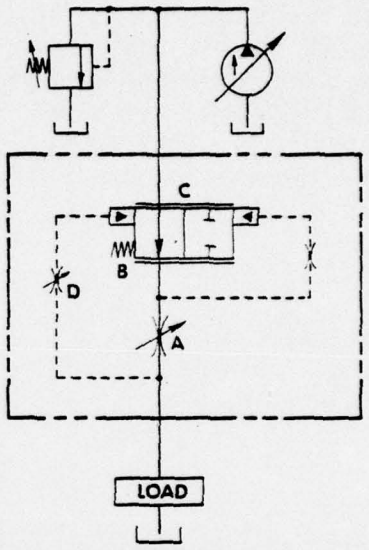
B. Bias Spring

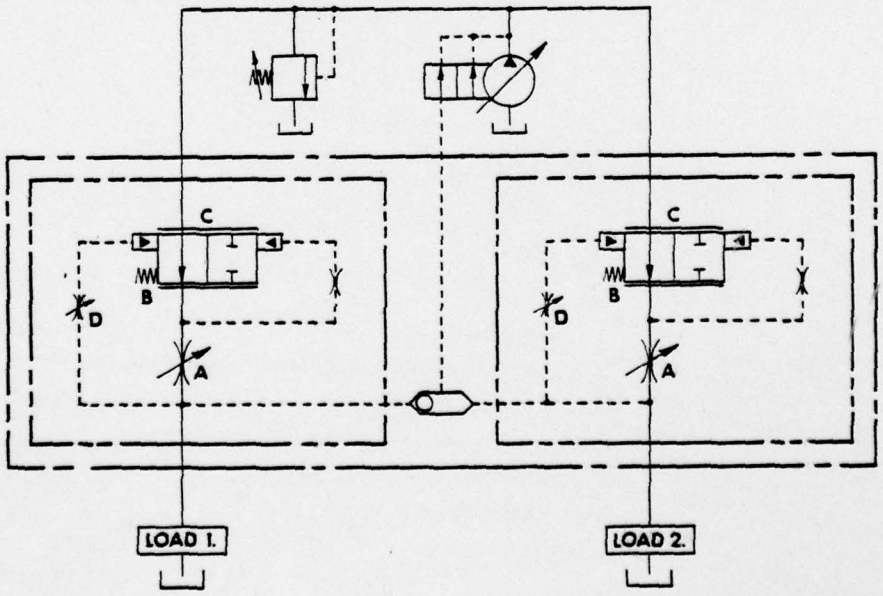
C. Pressure Reducing Compensator Spool

D. Dampening throttle

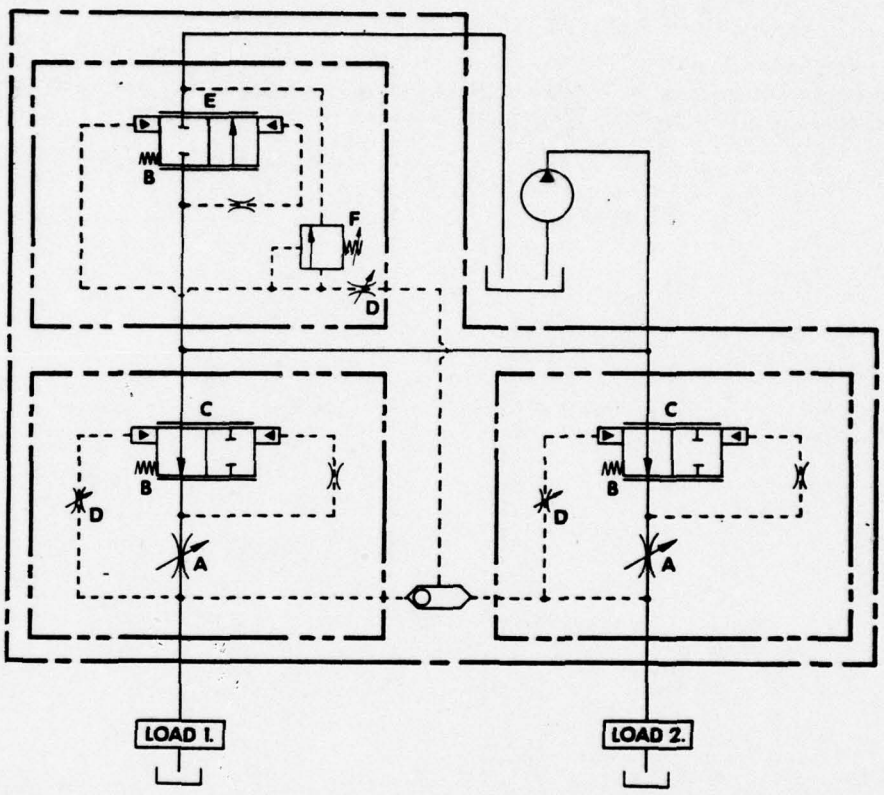
E. Unloading Valve Spool

F. Pilot Relief Valve





4



MCV-ISO SYSTEM WITH LOAD SENSING PUMP

This schematic shows two CDM Cartridge Compensators in parallel, permitting INDEPENDENT SIMULTANEOUS OPERATION of loads.

2

When all 4-ways are in neutral, the pump is at zero flow and at its bias pressure (typically 250 PSI). When the directional control valves (A) are shifted, each CDM compensator (C) controls flow to its respective 4-way (A). The internal shuttle valve system senses the highest load pressure and directs it to the pump control. The pump then strokes to the total flow requirement of the 4-ways, at a pressure equal to the highest load, plus pump bias pressure.

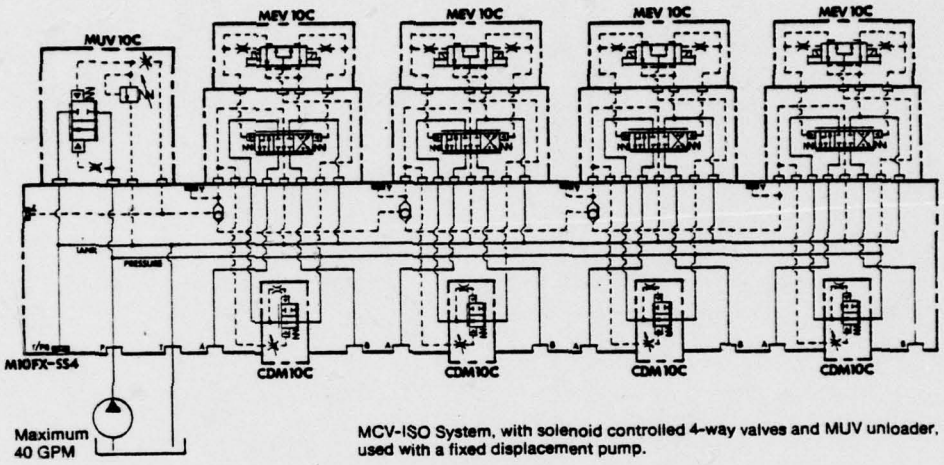
3

MCV-ISO SYSTEM WITH FIXED DISPLACEMENT PUMP

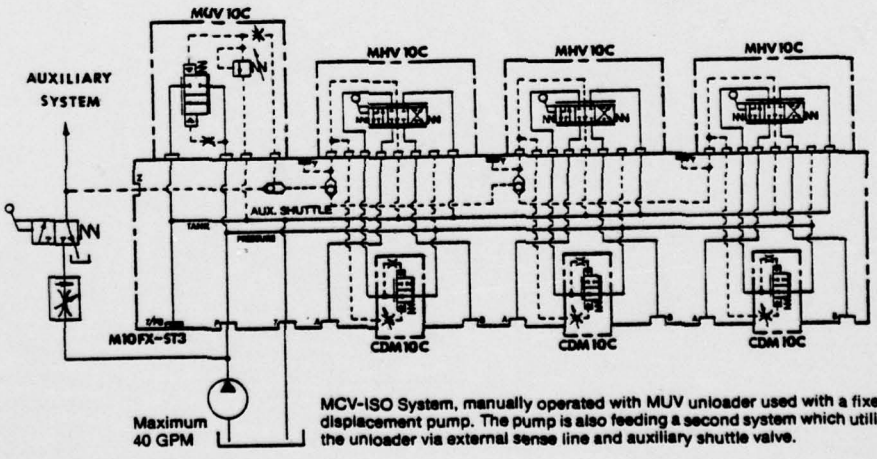
This circuit is similar to the load sensing pump circuit with the addition of the MUV unloading valve. The output load signal, sensed by the internal shuttle system, is directed to an unloading valve, or MUV, (E), which diverts excess pump flow to tank at highest load pressure plus bias pressure of the MUV. When the 4-way valves (A) are in neutral, the sense lines are vented to tank, so all flow from the pump passes thru our unloader (E) at bias pressure. The pilot relief valve (F) limits maximum system pressure, while the dampening throttle (d) limits pressure fluxuations.

5

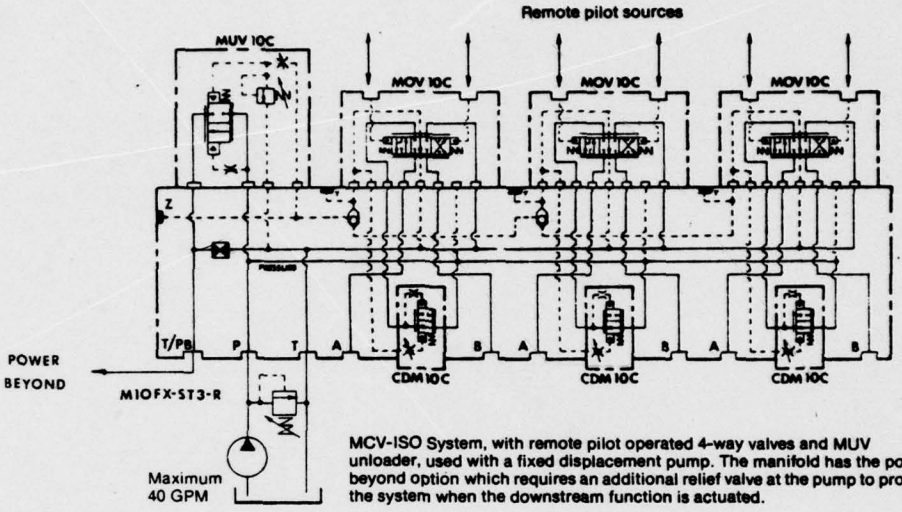
TYPICAL CIRCUITS



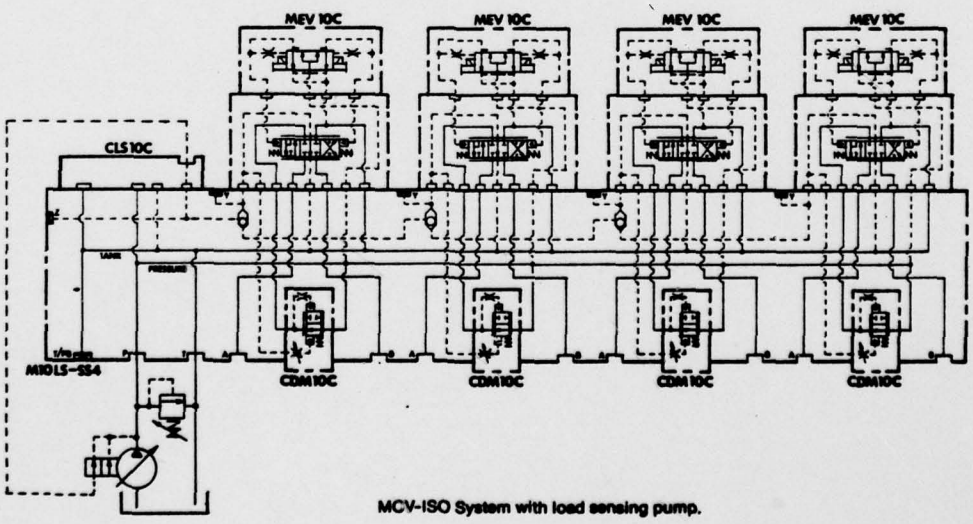
MCV-ISO System, with solenoid controlled 4-way valves and MUV unloader, used with a fixed displacement pump.



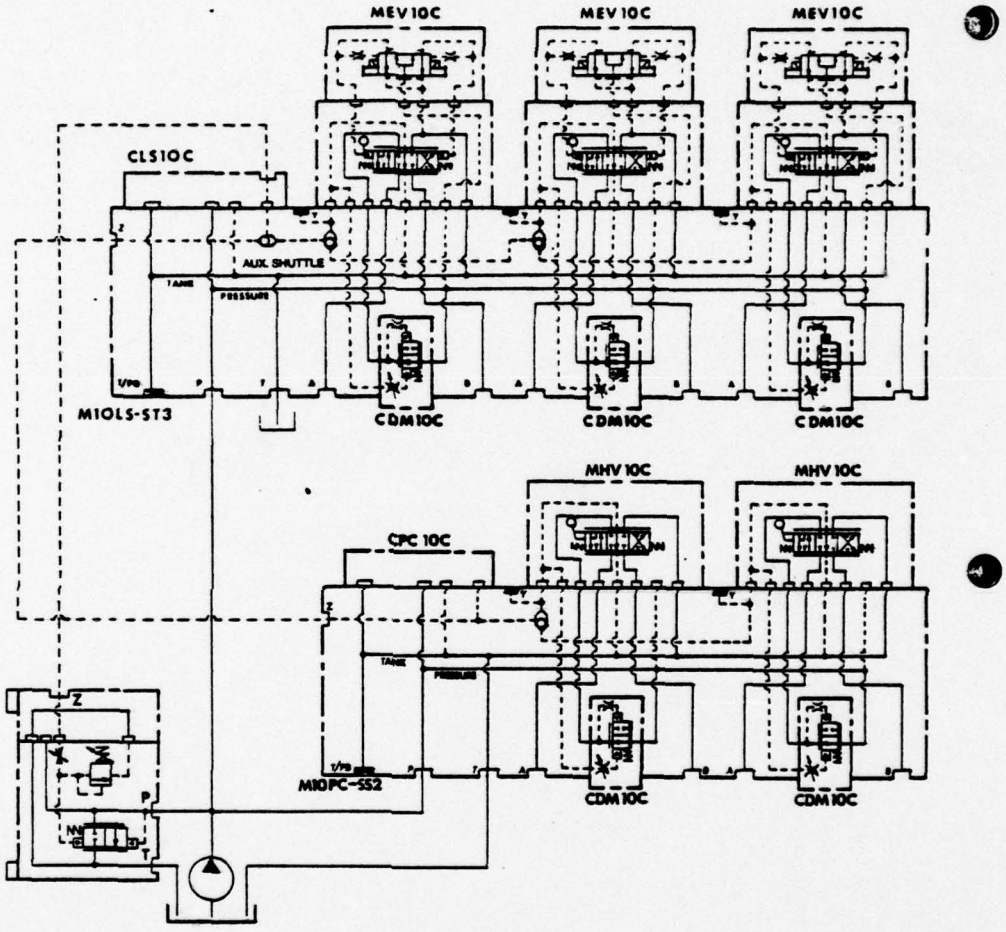
MCV-ISO System, manually operated with MUV unloader used with a fixed displacement pump. The pump is also feeding a second system which utilizes the unloader via external sense line and auxiliary shuttle valve.



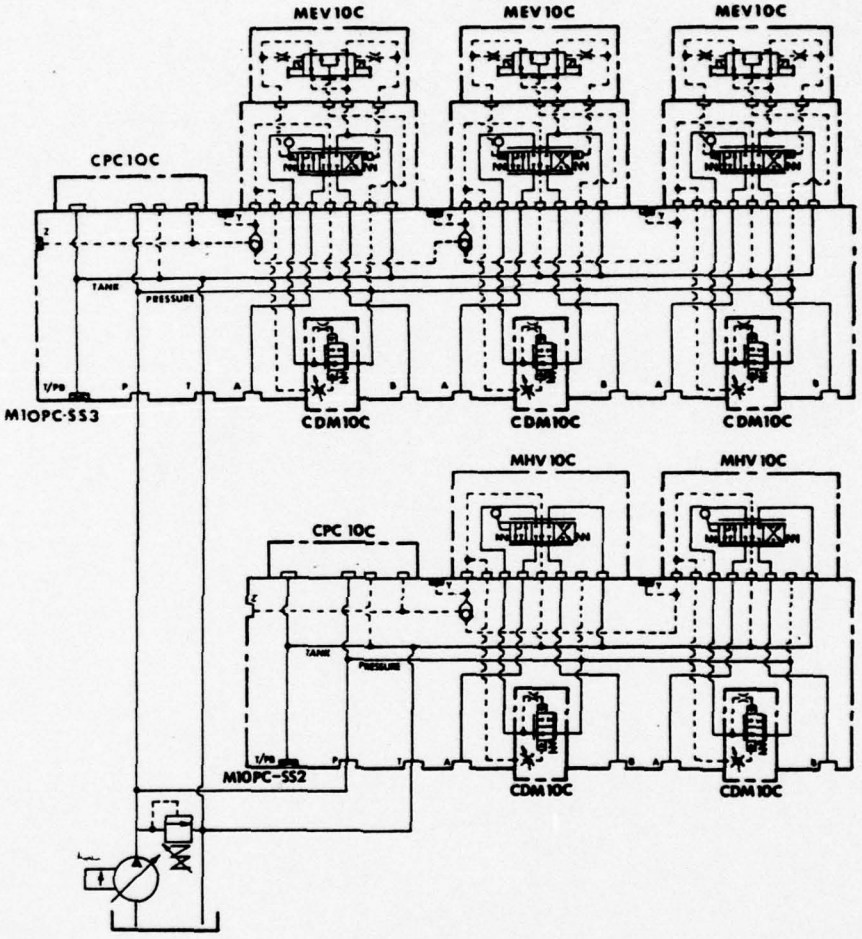
MCV-ISO System, with remote pilot operated 4-way valves and MUV unloader, used with a fixed displacement pump. The manifold has the power beyond option which requires an additional relief valve at the pump to protect the system when the downstream function is actuated.



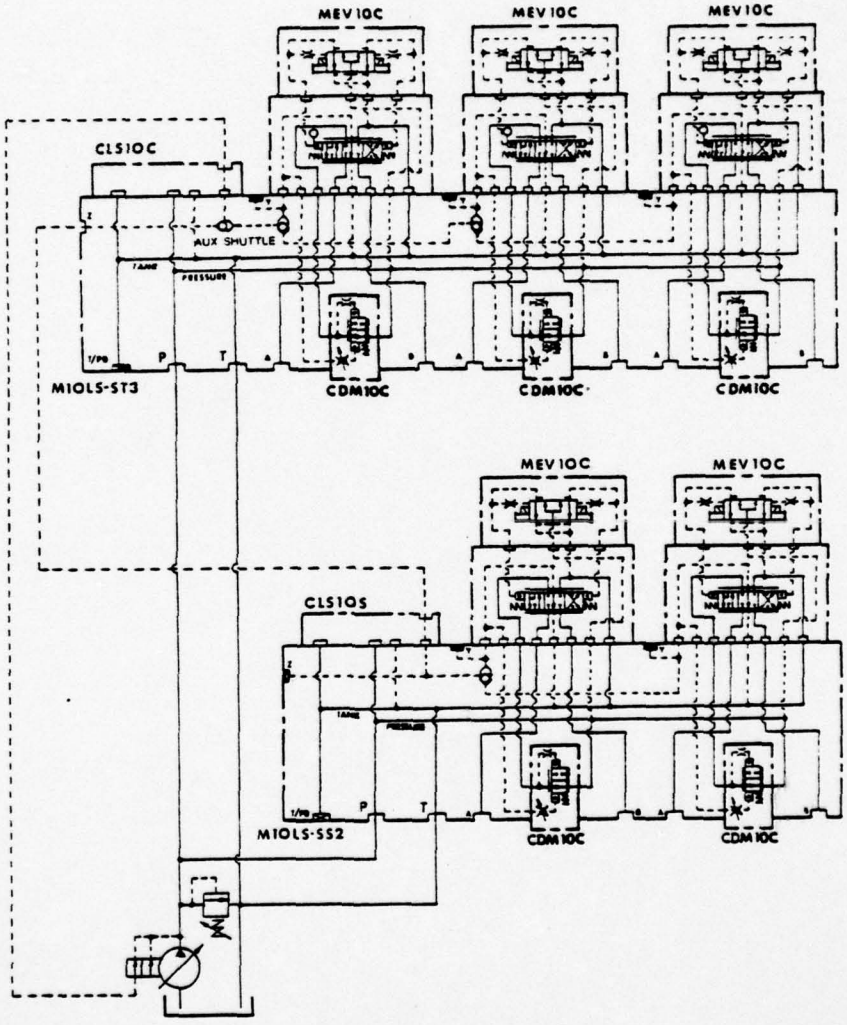
MCV-ISO System with load sensing pump.



Two MCV-ISO Systems, one solenoid controlled with manual override levers and one manually operated. The MUV unloader must be sized to handle total pump flow.
NOTE: If pump flow is less than 35 G.P.M., a MUV could be mounted on the manifold, with the auxiliary shuttle, in place of the CLS10C cover plate.

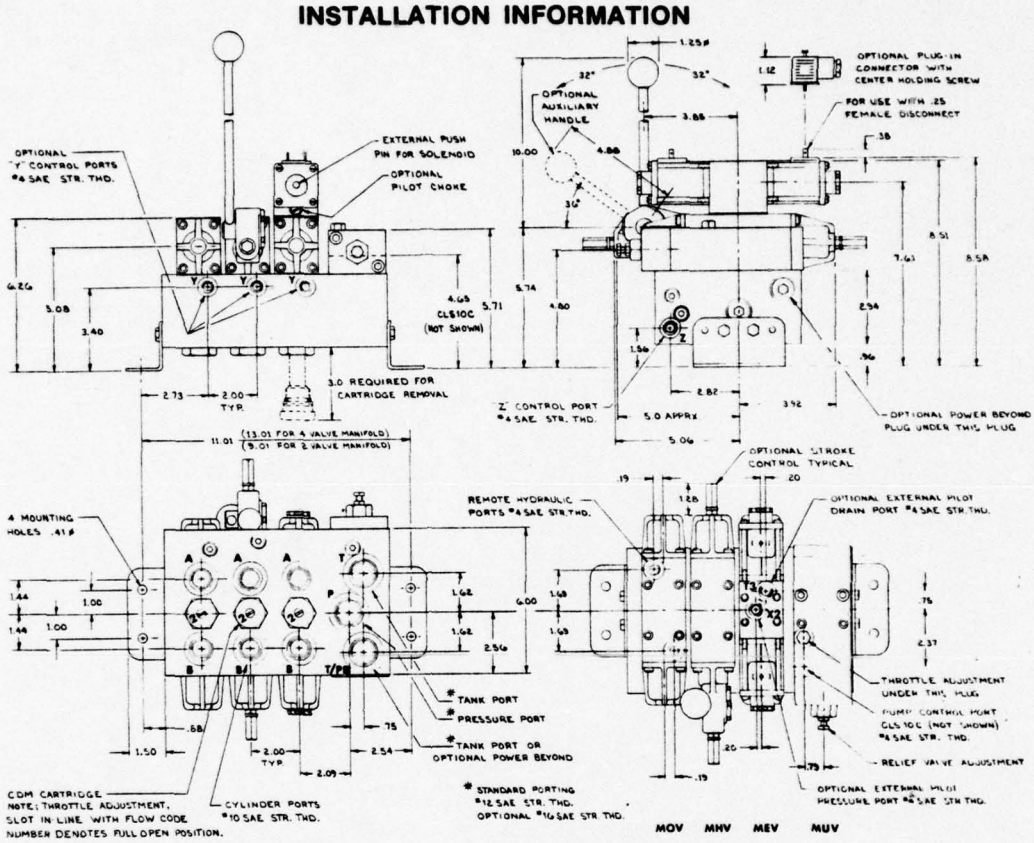


Two MCV-ISO Systems in parallel with a pressure compensated pump.



Two MCV-ISO Systems in parallel with a load sensing pump controlled thru the auxiliary shuttle valve.

INSTALLATION INFORMATION



ENGINEERING DATA

PERFORMANCE DATA

Pressure Rating 3000 PSI — 500 Maximum Tank
Flow Capacity 40 GPM Input and Return (Tank)

RELIEF VALVE RANGE

High Pressure 1200 to 3000 PSI
Low Pressure 200 to 1500 PSI

UNLOADING PRESSURE

85 PSI for 7 GPM Flow
150 PSI for flows above 7 GPM

SEALS

Buna n Seals Standard
Viton Seals Optional

REMOTE HYDRAULIC VALVES

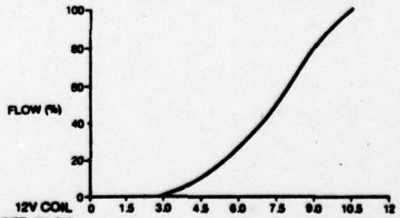
Remote Pilot Pressure
25 to 200 PSI
Output flows proportional to pilot pressure

ELECTRICAL DATA

All Solenoid Voltages are DC
Max. Power 22 Watts
12 Volt DC Standard
Other voltages available
24V/36V/48V/90V/180V

Solenoid Connections made with ¼" Female Spade Terminals
Plug in connector with center holding screw optional

FLOW VS SPOOL POSITION GRAPH



12V COIL	0	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12	VOLTS
REMOTE PILOT PRESSURE	21.4	38.7	59	73.3	89.6	107.9	126.2	142.5	159.8	PSI
HANDLE POSITION		3.2	6	12.8	17.6	22.4	27.2	32°		DEGREES

MANIFOLD — M10FX - S S 3 - R

Fixed Pump Manifold	M10FX				
Load Sensing Pump Manifold	M10LS				
Press. Comp. Pump Manifold	M10PC				
INLET PORTING *(all ports S.A.E. Str. Thd.)* T/PB / P / T					
12 / 12 / 12	Standard	S			
16 / 12 / 16		M			
16 / 16 / 16		L			
Standard Shuttle System			S		
Auxiliary Input Shuttle w/z Port			T		
NO. OF 4-WAY VALVES				2,3,4	
OPTIONS *(Specify only if required)*					
Plugged Optional Tank Port					P
Power Beyond					R
Viton Seals					V

INLET SECTION — CLS10C- L 8 S-V

Cover Plate (Load sensing)	CLS10C				
Cover Plate (Pres. Comp.)	CPC10C				
MUV Unloading Valve	MUV10C				
1500 PSI Relief		T			
3000 PSI Relief		L			
85 PSI Bias Pressure ①			6		
150 PSI Bias Pressure			8		
Pressure Adj. Screw				S	
OPTIONS *(Specify only if required)*					
Viton Seals					V

CARTRIDGE COMPENSATOR — CDM10C -1

Cartridge Compensator	CDM10C		
Flows Q1, Q2, Q3		1, 2, 3	

DIRECTIONAL CONTROL SECTION — MEV10C- L F F A 1 C -24

E	Electric 4-way	MEV10C							
M	Manual 4-way	MHV10C							
R	Remote Hyd. 4-way	MOV10C							
	3000 PSI Press. Rating.		L						
R/E	Spring Centered Proportional			F					
M/E	Spring Centered On-Off			N					
M	No Spring			O					
M	One Position Detent Center			B					
M	Two Position Detent			T					
M	Three Position Detent			R					
M	Center Position Detent w/Friction Lock			L					
E	Sgl. Solenoid On-Off			J					
E	Sgl. Solenoid Proportional			K					
E	Double Solenoid On-Off			N					
E	Double Solenoid Proportional			F					
R	Std. Cap Both Ends - MOV			O					
M	Vertical Handle Position (A Side) ②			S					
M	Horizontal Handle Position (A Side) ②			W					
	Standard (Flow Pattern) ④				A,C				
	Standard Flows ④ ⑤				1, 2, 3				
	Special Flows ④ ⑧				4				
OPTIONS *(Specify only if required)*									
E	Pilot Chokes					C			
	Stroke Controls					H			
R/E	Auxiliary Handle (A Side) ②					L			
	Viton Seals					V			
	Remote Pressure Control Port					Y			
E	External pilot supply					X2			
E	External pilot drain					T3			
E	Solenoid 12VDC Std. ⑦ ⑧								24
E	Solenoid Connector								12D
	Optional solenoid voltages specify 24V 36V 48V 90V 180V (All Coils DC)								

E - Pertains only to Electric Valves.
M - Pertains only to Manual Valves.
R - Pertains only to Remote Hydraulic Valves.

FOOTNOTES

① Q1 Flow only

② Handle on B side available

④ *Standard spool flow pattern*



⑤ Standard spool and CDM comp.
Q1 7gpm max.
Q2 13gpm max.
Q3 21 gpm max.

⑤ CDM must be consistent with flow requirement

⑧ Other than standard spools available

⑦ Optional solenoid voltages specify
24V 36V 48V 90V 180V (All Coils DC)

⑧ For electrical characteristics see HPI Bulletin HPC 115

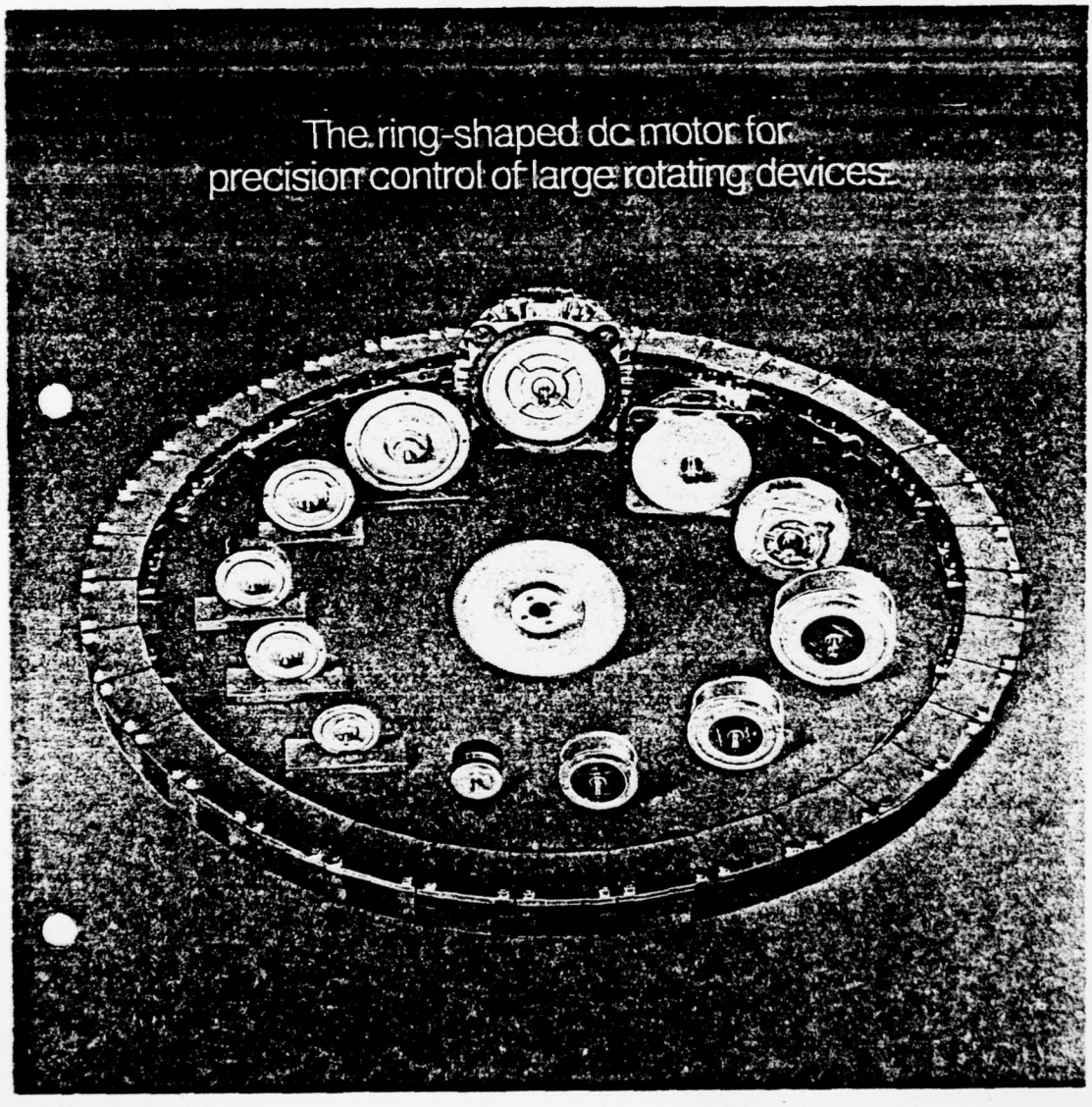
HOW TO ORDER (EXAMPLE)

1. M10FX-SS3-R	Manifold
2. MUV10C-L8S	Inlet (MUV or Cover Plate)
3. 2850 PSI Relief Setting	(If not specified 2500 PSI)
4. MEV10C-LFFA1-C-L-12	Directional Control Next To Inlet
5. CDM10C-1	Cartridge
6. MEV10C-LFFC3	Directional Control
7. CDM10C-3	Cartridge
8. MOV10C-LFFC2-L	Directional Control
9. CDM10C-2	Cartridge
10. MHV10C-LNSA1-H	Directional Control
11. CDM10C-1	Cartridge

HPI Nichols
a W. H. NICHOLS COMPANY
7900 Durand Ave. P.O. Box 458
Sturtevant, Wisconsin 53177 414/554-8818 Telex 26-4446

Printed in U.S.A. HPC-131

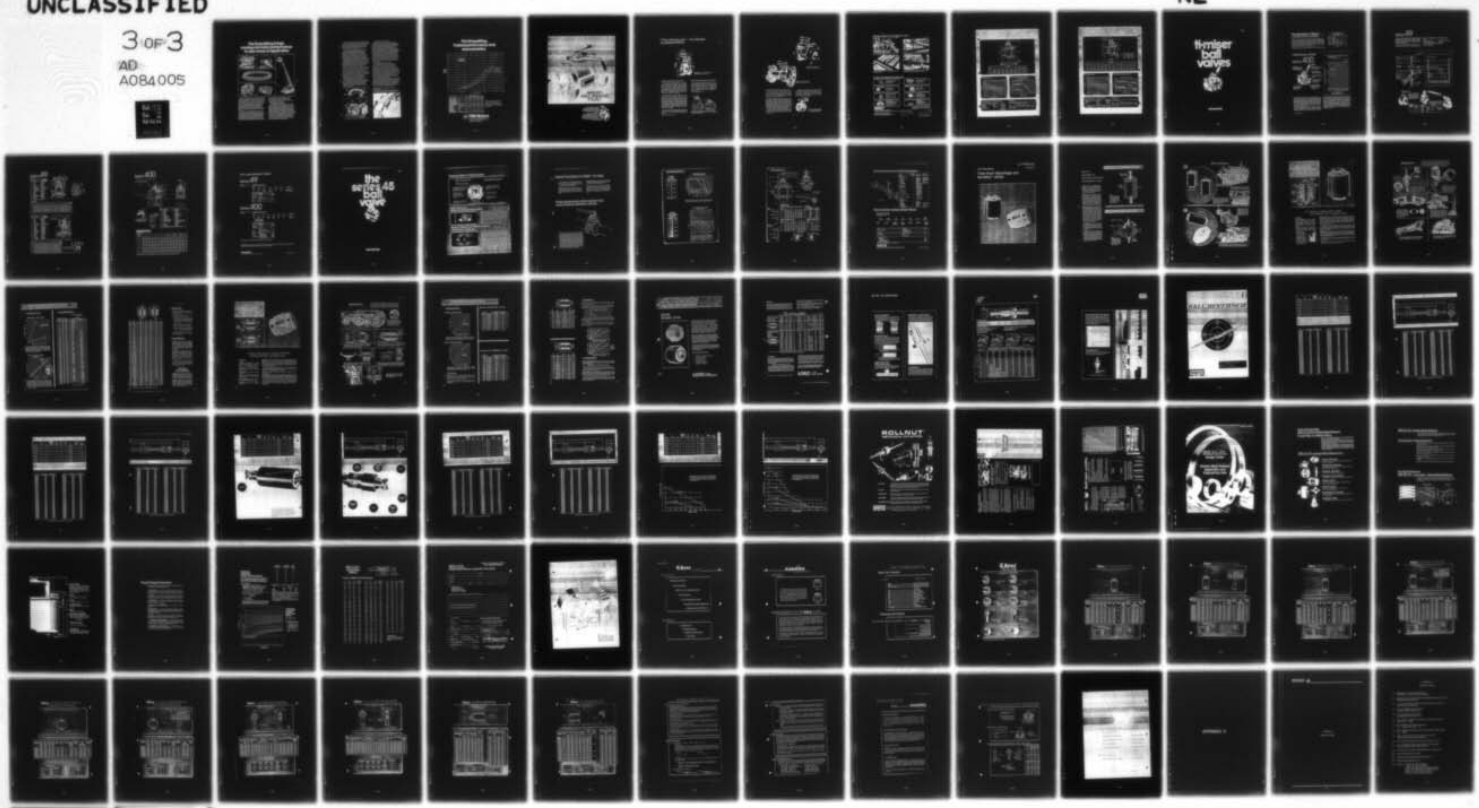
Introducing TorqueRing™



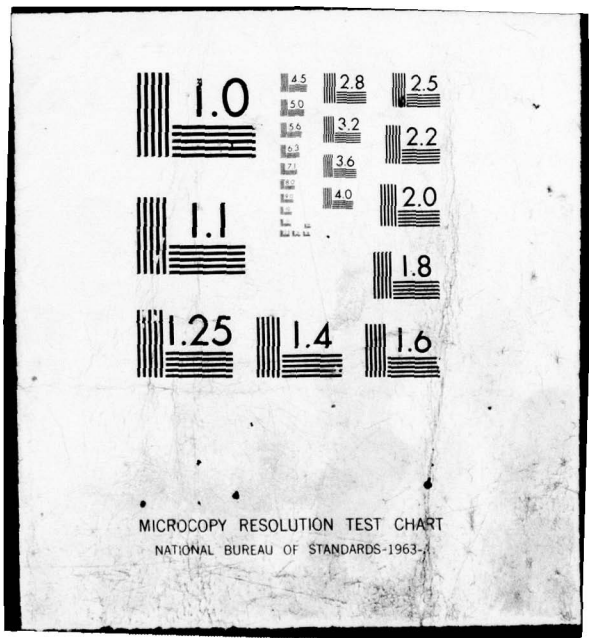
AD-A084 005 GOULD INC GLEN BURNIE MD CHESAPEAKE INSTRUMENT DIV F/G 13/10.1
DEPLOY/RETRIEVE STORAGE SYSTEM (DRSS). VOLUME II. PART II. COMP--ETC(U)
1980 N00039-79-C-0329

UNCLASSIFIED NL

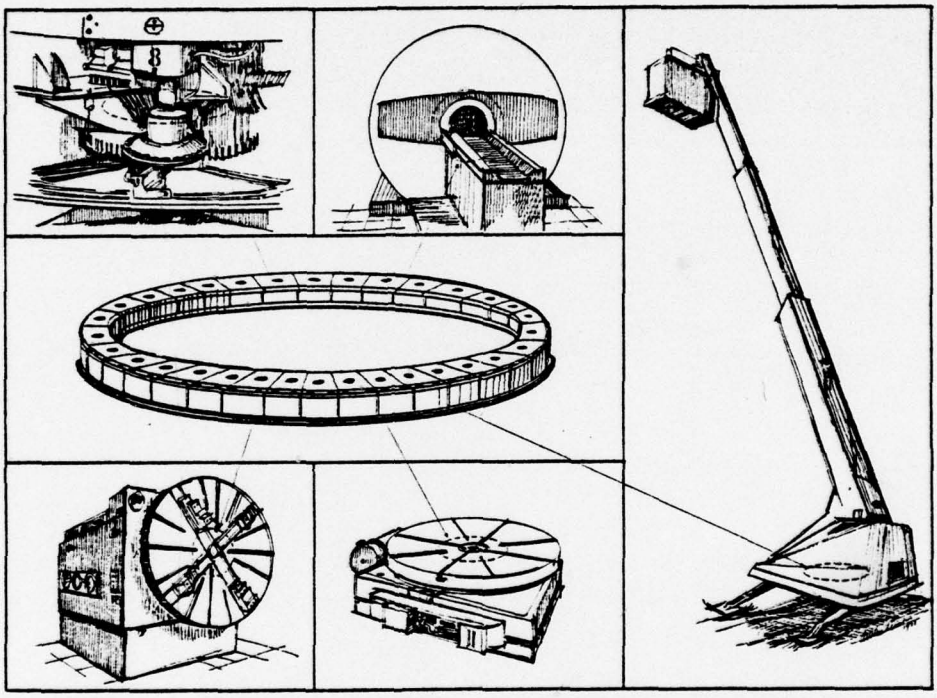
3 OF 3
AD
A084005



END
DATE
FILMED
6-80
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
7.1
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The TorqueRing brings moving coil motor performance to new areas of application



The PMI TorqueRing makes it possible to direct-drive large rotating loads with moving-coil dc motors. Design engineers involved with motion control applications for over 15 years have used moving-coil motors for precise rotary motion because they are linear transducers of electrical to mechanical energy with a straight line speed/torque curve. Also, the high pulse torque capability and low inertia of moving-coil motors has greatly increased the performance of precision motion control.

Up to this time, most applications for moving-coil motors were in the fractional horsepower range. The TorquePing extends moving-coil motor technology into a wide variety of new areas by utilizing large diameter configurations of the unique printed armature. Now, high-speed incrementing, precise control of varying speed requirements and extremely accurate positioning can be achieved in such applications as rate tables, automated cranes, telescopes, flight simulators, large machine tools, X-ray equipment indexing tables and web drives.

TorqueRing construction.

The configuration of the TorqueRing is somewhat similar to a torquer in that it is shaftless. The armature attaches directly to the rotating load with a modular permanent magnet stator structure mounted on the stationary portion of the equipment (see construction drawing). Another way to visualize the TorqueRing is as a linear motor bent in an arc which closes on itself. The radius of the arc is limitless starting from a minimum of 12 inches. To date, the largest motor designed and tooled is 72" in diameter but maximum size is limited only by the economic aspects of special tooling and handling equipment for manufacturing.

Typically the cross section of a TorqueRing motor is a 7" by 7" square which is constant for any motor diameter chosen. For requirements where space is at a premium, rare earth magnet materials may be used to reduce the height of the cross section to approximately 5".

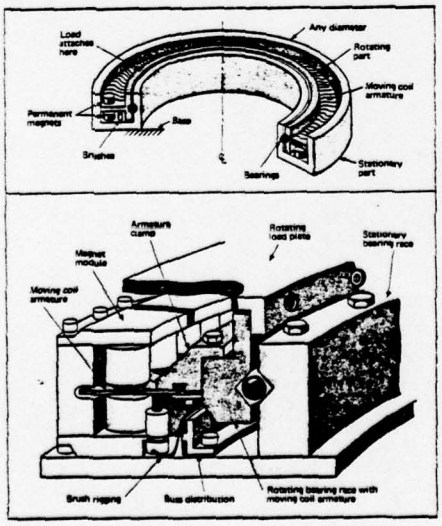
Performance characteristics.

By incorporating the same basic printed armature principles and permanent magnet axial air gap construction, the TorqueRing motor offers all the performance advantages found in PMI's fractional horsepower motors. Perhaps most important is the capability of direct drive of the load with no gearing, linear performance and straightforward servo control.

The TorqueRing is capable of very high peak torques, with ratings determined by thermal considerations, not demagnetization of the field. Peak torques of 20 to 25 times rated torque are typical so that rapid acceleration of the load is possible. Because the electrical time constant of moving coil motors is usually in the microsecond range, peak torque is instantly available to operate on the load and the mechanical time constant.

The low inductance of the armature is evident in commutation with virtually no brush arcing, even at very high pulse current levels. This results in very long brush life, usually eliminating any brush changing for the life of the assembly. With no arcing, radio frequency interference is very low, usually within military and commercial specifications with no filtering.

The armature of the TorqueRing motor is light in weight, typically two pounds per foot of circumference. Since it is ironless, there is no magnetic detenting, cogging or preferred armature positions. Each conductor is a commutator bar providing extremely smooth torque output.



Advantages over hydraulics.

Although hydraulic drives have dominated large device motion control to date, they have disadvantages, one being the necessity for gearing and its associated backlash problems. Hydraulic drives also require precision valving, ultra-clean fluid, precision filters, a pump, radiator, reservoir and high-pressure hoses and fittings which occasionally leak. In many applications, the noise of hydraulic servos can be a significant problem.

The TorqueRing motor completely eliminates these disadvantages. Coupled directly to the load, it has no backlash and provides faster, more precise response. It is less complex and therefore less likely to malfunction or require field maintenance. Space is saved by the elimination of plumbing hardware and acoustical noise is greatly reduced.

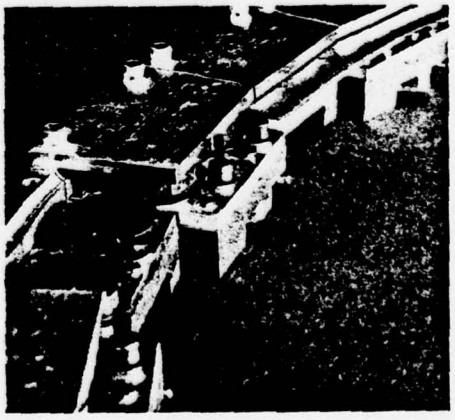
Advantages over torque motors.

Although torque motors eliminate the gearing problems of hydraulics, they also have inherent weaknesses. First, torque ripple and cogging at low speeds. Second, limited peak torques for acceleration, and plugging for deceleration, due to the possibility of demagnetization. Third, substantial electrical inductance and resulting electrical time constants which limit speed of response. And, finally, torque motors are heavy. Their armature configuration adds substantial weight to the rotating structure, increasing bearing load and, more important, the rotating load inertia.

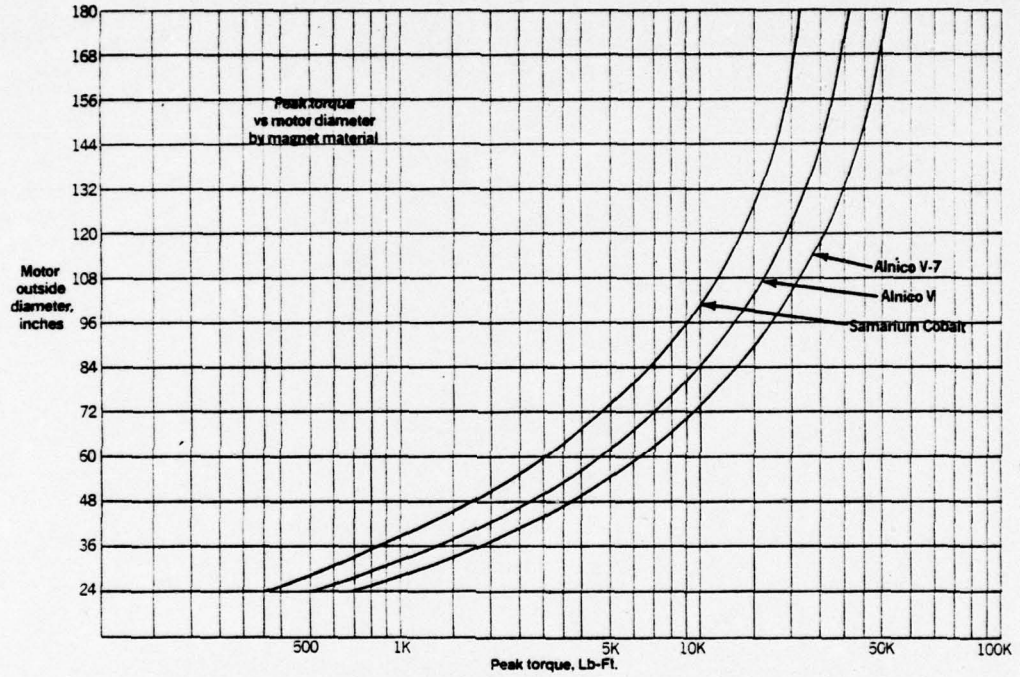
With no rotating iron, the TorqueRing motor has limited torque ripple and no cogging, much higher peak torque capability and negligible inductance. With its lightweight armature, the rotating components in a TorqueRing motor will typically weigh considerably less than those of a torque motor with a comparable output rating.

At left: Basic construction configuration of a complete TorqueRing Motor.

Below: Sub-assembly for a 5' diameter motor showing unmounted magnet modules, brush rigging and a section of the armature.



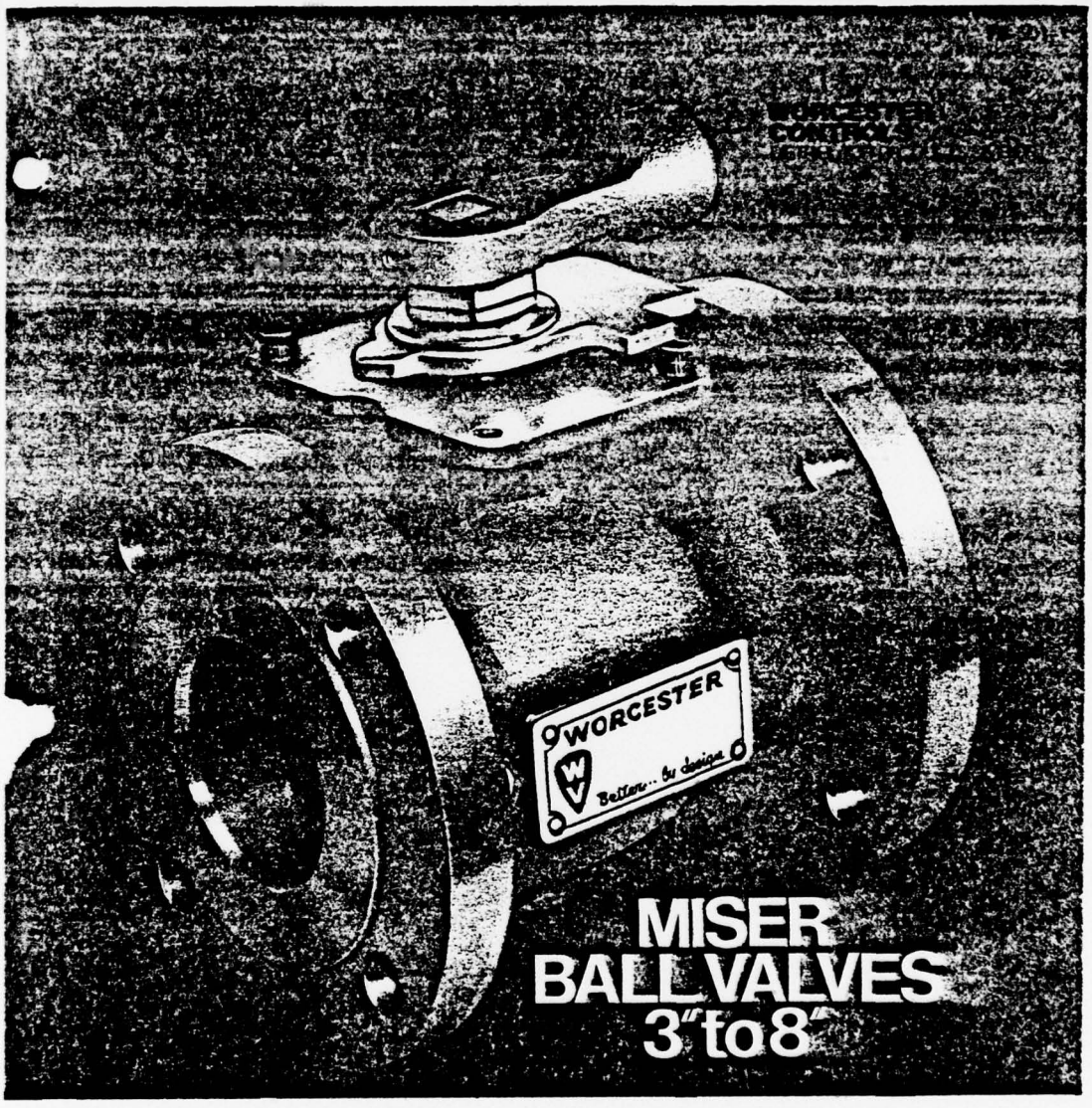
The TorqueRing: Typical performance and characteristics



Constants/ratings	Units	Models: OD/ID (in feet)				
		2/.5	4/2.5	6/4.5	8/6.5	10/8.5
Peak torque @ 25°C	Lb-Ft	720	3800	9400	17,300	27,800
Continuous torque	Lb-Ft	170	880	2100	4000	6200
Terminal voltage for peak torque @ stall	Volts	97	228	178	240	305
Motor constant @ stall	Lb-Ft/$\sqrt{\text{Watts}}$	5.2	18.0	35.2	55.8	80.0
Torque sensitivity	Lb-Ft/Amp	3.7	19.4	23.7	44.0	70.3
Back EMF	Volts/Rad/Sec	5.0	26.2	32.0	59.5	95.3
Electrical time constant	Milli-Sec	0.5	0.5	1.5	1.6	1.6
Armature resistance @ 25°C	Ohms	0.5	1.1	0.5	0.6	0.8
Armature inertia	Lb-Ft-Sec^2	0.25	2.7	10.2	25.7	53.0

PMI Motors is ready to assist you in sizing a TorqueRing for your application. For further information, call or write the TorqueRing Product Group at PMI.

PMI Motors
Division of Kollmorgen Corporation
5 Aerial Way, Syosset, New York 11791
Telephone: 516-938-8000

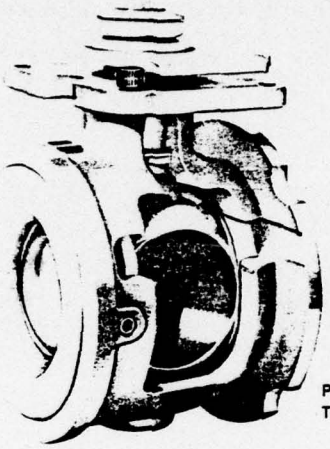


ANSI Dimension Valves
Unit body construction with integrally cast flanges. Bottom entry stem design permits seal adjustment to compensate for wear and temperature fluctuations in service.

Short Pattern Valves
Compact configuration, with 40 to 60 percent weight savings. Miser short pattern is easily inserted between two standard flanges which are then bolted together. Wide choice of seats, seals and body materials to fit most temperature-pressure requirements.



"Two valves in one"... the ultimate in piping flexibility



PRESSURES UP TO 1000*** psi WOG
TEMPERATURES UP TO 450°F.

1. Miser* Short Pattern Ball Valve

The Miser Short Pattern serves as "2 valves in 1". The center section is simply and quickly inserted between *two standard flanges* (either 150# or 300#) and the flanges bolted together. Almost any media within the temperature-pressure limitations can be handled by the short pattern Miser because it offers a wide choice of seats, seals and body materials. Both the Miser 151 and Miser 301 are available specially adapted for either oxygen or high-vacuum service.

Original costs are less and maintenance is less with the Miser Short Pattern. Yet, this valve offers you all the unique advantages of the standard Miser: the downstream seat sealing, lower torque, longer life, bottom entry blow-out proof stem with the adjustable self-compensating stem feature of Misers. Unique design end-plug for easy field maintenance. Machining of retaining grooves allows random assembly of end plug. No presses are required. Design provides uninterrupted gasket surface permitting use of all standard type gaskets.

You get positive shut-off, easier operation, longer valve life and faster maintenance if necessary when you use Miser Short Pattern Ball Valves.

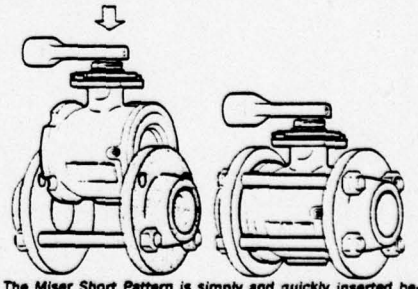
*Trademark of Worcester Valve Co., Inc.

Minimum Space Requirements-Check This!

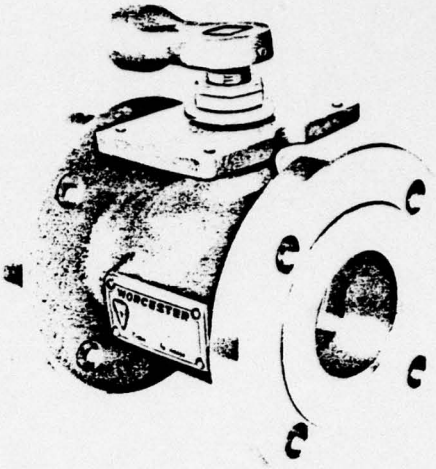
The weight of Miser Short Patterns is 40% to 60% less than conventional USAS** ball valves. Their configuration is a lot more compact, too. The center to top dimension of a 4" Miser is only $6\frac{3}{16}$" as opposed to $27\frac{3}{4}$" for a standard gate valve... valuable space savings to original equipment manufacturers and in new installations.

**USAS formerly ASA

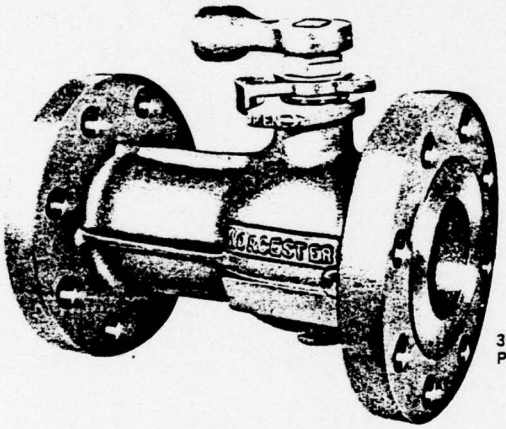
*** 720 psi for bronze and aluminum



The Miser Short Pattern is simply and quickly inserted between two standard flanges as shown. Correct studs and nuts furnished with valve.



150 LB. USAS DIMENSION
PRESSURE RATING 275 psi



300 LB. USAS DIMENSION
PRESSURE RATING 720 psi

2. Miser ANSI* Dimension Ball Valve

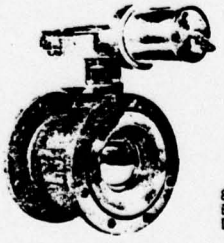
Only Worcester offers you everything from 3" to 8" in USAS dimension ball valves. All feature the Miser's positive, bubble-tight shut off, blow-out proof stem, low operating torque, reduced installation and maintenance costs.

The Miser ANSI* Dimension Ball Valve (3"-4"-6"-8") has unit body construction with integrally cast flanges. It features greater port area for greater flow, uniform wall thickness to eliminate thin, unsafe sections as well as USAS face to face dimension for full size range. The Worcester downstream sealing, patented seats in the Miser USAS allow low torque and longer life over a wider pressure-temperature range.

A unique bottom entry stem design permits seal adjustment to compensate for wear and temperature fluctuations while the Miser is in service.

*USAS formerly ASA

The Miser USAS Ball valve is another example of Worcester "better by design" capability. It is also another opportunity to save maintenance, installation and "downtime" costs in the field or plant where USAS dimensions are an integral part of your piping system.

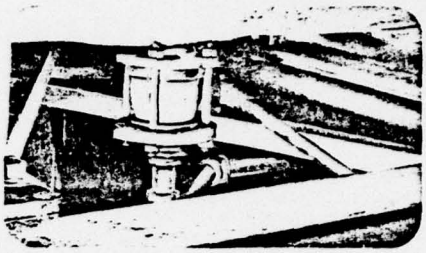


8" 150 lb. USAS Dimension Ball Valve shown with Series D34 Pneumatic Actuator.

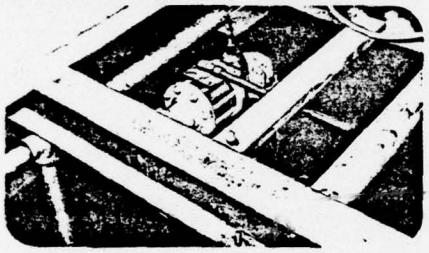
APPLICATIONS OF THE MISER 3" TO 8"



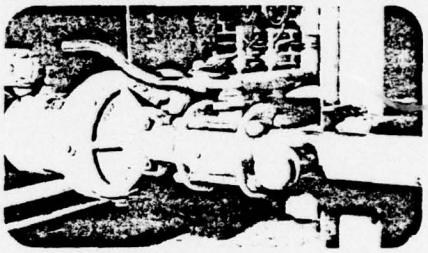
Miser ball valves replaced gate valves in fermenting tank cooling lines handling glycol at 15°F.



Compact short pattern miser excellent for use as a tank bottom dump valve.



Compact miser short pattern in chilled water lines of new *aircraft paint hanger.*



A 3" stainless steel Worcester ball valve is employed as a pump shut-off valve on the reactors outlet line.

OTHER WORCESTER PRODUCTS



Econ-O-Mite™ Ball Valve
Ratings to 500 psi.
Size range ¼" to 2"



Worcester 600 Ball Valve
Ratings to 600 psi
Size range ½" to 2"



Miser® Ball Valve
Ratings to 3000 psi.
Size range ¼" to 2"



Miser Fire Valve
Ratings to 1000 psi
Size range ¼" to 2"



Disc-O-Seal®• Butterfly Valve
Ratings Hi-vac to 150 psi.
Size range 2½" to 12"



Series 33 and 34 Pneumatic Actuators
Tailored torque to fit ball and butterfly valves.



Mark III Series 38 *Flowmate Valve Actuators*
Pneumatic on/off and throttling service with ball or butterfly valves.



***Flowmate®* 35 Electric Actuators**
Available in general purpose, weather-tight, and explosion-proof configurations.

WORCESTER CONTROLS
DISTRIBUTOR PRODUCTS DIVISION
125 HARTWELL STREET, WEST BOYLSTON, MASSACHUSETTS 01583, PHONE (617) 835-6041

Worcester maintains manufacturing and/or sales offices in England, Canada, Mexico, Brazil, Argentina, Australia, West Germany, Belgium, Switzerland, France and South Africa.

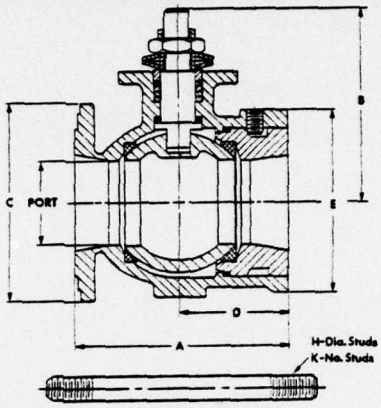
The above Worcester products are manufactured under one or more of the following patents: 2,895,496; 2,930,576; 2,963,263; 3,460,799; 3,369,791 and 3,348,805.

1340 list 316SS
9691 . ST Titanium
(6"-151-301)

11/13/79
Dick Turcotte
Paul Colt
215-269-6451

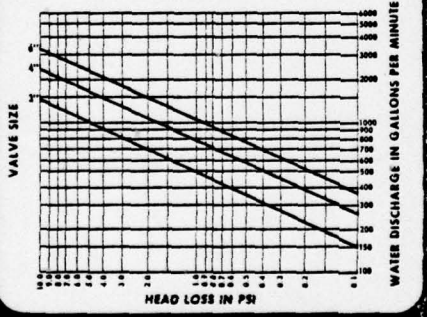
MBV 10-73-10M Printed in U.S.A.

Specifications: short pattern ball valve

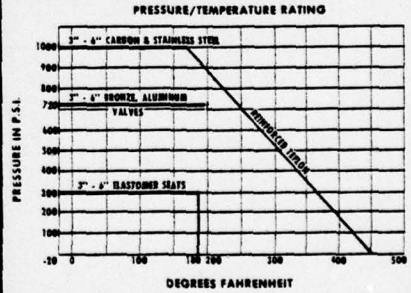


VALVE SIZE	DIMENSION A	B	C	D	E	Port	150# H	150# K	300# H	300# K
3"	4.50	5.69	5.88	2.25	5.38	2.50	.62	4	.75	8
4"	5.81	6.31	7.50	2.94	6.88	3.25	.62	8	.75	8
6"	7.38	8.94	9.88	3.69	8.75	4.38	.75	8	.75	12

Head loss vs. flow



Pressure-temperature rating



Ordering Code - Short Pattern

Body, End Plug, Ball & Stem		Seats & Seals		Type
Bronze	1	Buna	B	151 — for use between 150 USAS flange.
Ductile Iron	2	Teflon	T	
Aluminum	3	Reinforced Teflon	RT	301 — for use between 300 USAS flange.
Carbon Steel	4			
316 Stainless	6			

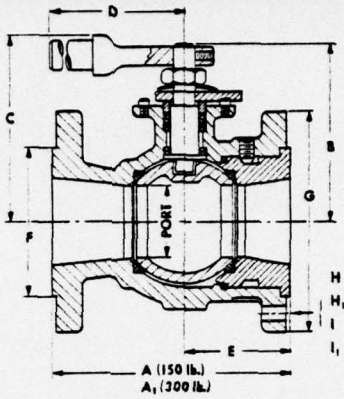
Ordering Example:

3" Style 44 Miser Short Pattern, Bronze body, end plug, 316 S.S. ball and stem, reinforced teflon seats, teflon body seal:

Size	Style	Body, End Plug	Ball & Stem	Seats/Seals	Type
3"	4	1	6	RT	151

Order: 3" 416 RT-151

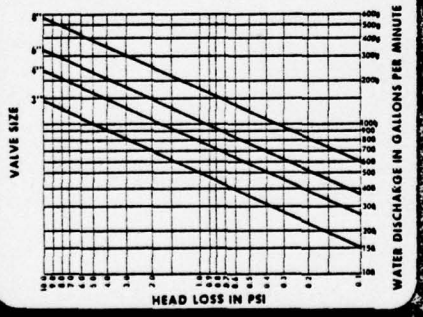
Specifics of the miser-flanged ball valve



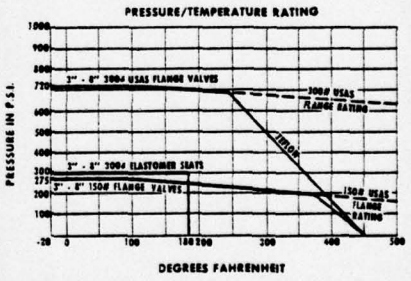
H – No. OF HOLES (150 lb.)
H1 – No. OF HOLES (300 lb.)
I – DIA. OF HOLES (150 lb.)
I1 – DIA. OF HOLES (300 lb.)

	DIMENSION												
SIZE	A	A1	B	C	D	E	F	G	Port	H	H1	I	I1
3"	8	11⅛	5¹¹⁄₁₆	6⅛	22¾	3⅜	5	7½	2½	4	8	¾	⅞
4"	9	12	6¾	6¾	22¾	4	6¾	9	3¼	8	8	¾	⅞
6"	10½	15⅞	8¹³⁄₁₆	9¼	33¾	4¼	8½	11	4⅜	8	12	⅞	⅞
8"	11½	16½	10¹⁄₁₆	10⅜	33¾	5⅜	10⅜	13½	5¹¹⁄₁₆	8	12	⅞	1

Head loss vs. flow



Pressure-temperature rating



Ordering Code - Flanged Miser

Body, End Plug, Ball & Stem		Seats & Seals		USAS* or MSS Pressure Class
Ductile Iron	2	Buna	B	150# or
Carbon Steel	4	Teflon	T	300# length
316 s.s.	6	Reinforced Teflon	RT	

Note: Stainless steel flanged valves have flat face flanges per MSS specifications, all others have 1/16" raised face per USAS (formerly ASA) specifications.

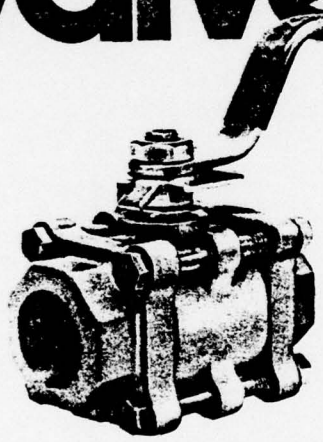
Ordering example:

8" Carbon steel body, end plug, ball & stem, 150# flanged, with teflon seats and seals.

Size	Style	Body, End Plug	Ball & Stem	Seats/Seals	Type
8"	4	4	4	T	150

Order: 8" 444T-150

ti-miser™ ball valves

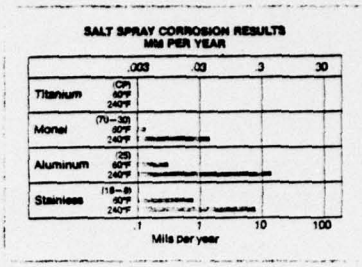


WORCESTER

The Worcester Ti-Miser™ . . .
for naturally corrosive environments

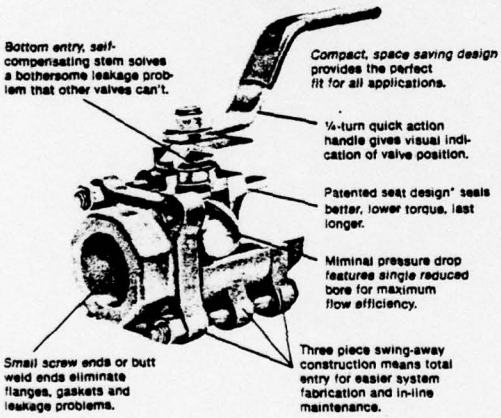
Titanium is well known for its light weight and high strength. Titanium also features outstanding corrosion resistance to many natural environments. It is highly resistant to sea water, acid mine wastes, fruit juices and syrups, and to such chemicals as sulfides, hypochlorides, nitric acid, chlorine dioxide, "wet" chlorine and chloride salts.

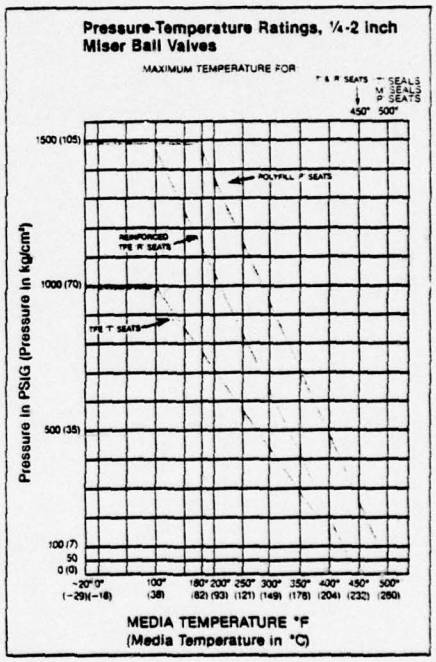
Worcester offers two styles of titanium "Ti-Miser" Ball Valves.



TITANIUM BALL VALVES

Series 400





The Worcester Ti-Miser is an Econ-O-Miser® at heart: a two-way flow ball valve featuring a rugged three piece construction that's easy to maintain and adapts to virtually any piping system and configuration. Wherever the demand is tough, be it applications for salt water, acids or harsh chemicals, the Ti-Miser can provide dependable, long term service now and for the future.

But, the features that make the Ti-Miser different, make an important difference in reliability and cost effective performance. More specifically, it means a versatile, high performance, long life ball valve for many demanding process applications. And above all it means a substantial savings in both installed costs and maintenance costs when compared to alternate valves. And that kind of cost efficiency adds up to extra dependability and profits for you.

The Series 400 is available in screwed end or butt-weld for schedules 5, 10 or 40, for easy installation in titanium systems without the necessity of expensive flanges or unions.

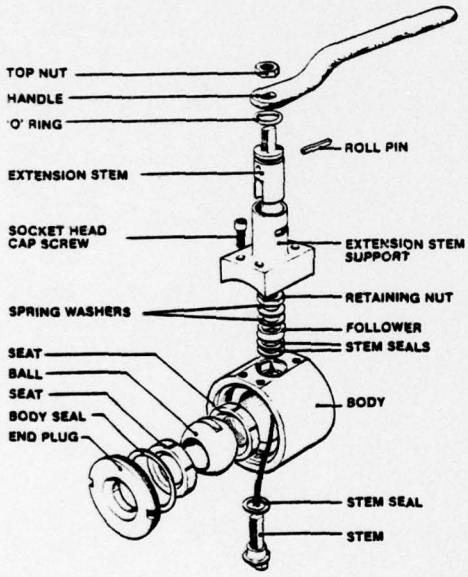
*Patent No. 2,930,576

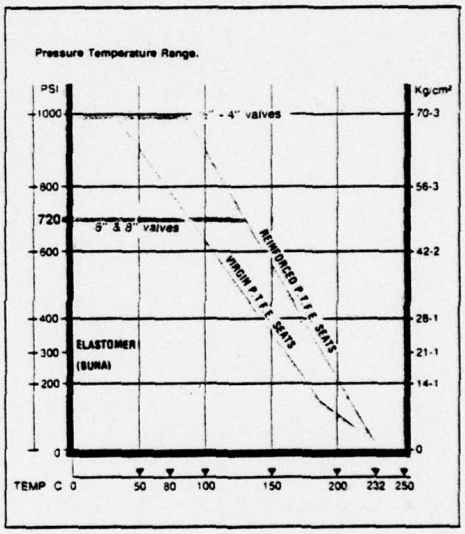
Series 49

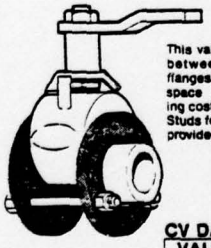
The unique wafer design of Worcester's Series 49 titanium ball valve uses minimum wetted surfaces, and features the Miser sealing package, resulting in high performance at minimum material cost.

Now you can enjoy all the advantages of the famous Miser ball valve in corrosive service beyond the capabilities of conventional ball valves:

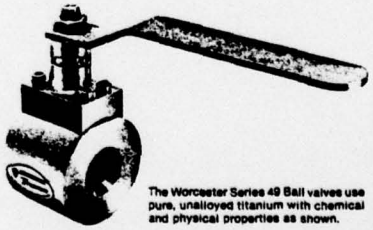
- Leaktight shutoff
- Quarter-turn operation
- Visual indication of valve position
- Easily automated
- Bottom entry system
- Compact







This valve is designed to fit between standard #150 flanges, with a minimum space requirement, effecting cost and weight savings. Studs for flange make up are provided with the valve.



The Worcester Series 49 Ball valves use pure, unalloyed titanium with chemical and physical properties as shown.



CV DATA

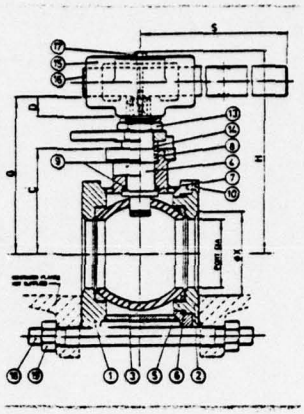
VALVE SIZE	CV (GPM)
½"	8
¾"	12
1"	32
1½"	80
2"	104

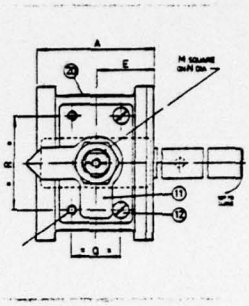
Chemical		Mechanical	
125 (Grade 1)		125	
.20 max	Oxygen	25-36 tf/ins.²	Tensile Strength
.10 max	Carbon		
.03 max	Nitrogen	15 tf/ins.²	Proof Stress
.013 max	Hydrogen	19%	Elongation
.20 max	Iron		
Balance	Titanium		

Series 49

3" - 8"

ITEM NO.	DESCRIPTION	MATERIAL SPECIFICATION
1	Body	Titanium 125
2	Insert	Titanium 125
3	Ball	Titanium 125
4	Stem/Stem Pin	Titanium 125
5	Seat	PTFE Virgin
6	Insert Seal	PTFE Virgin
7	Stem Thrust Seal	PTFE 25% glass filled
8	Gland Packing	PTFE 25% glass filled
9	Stem Location Ring	Titanium 125
10	Insert Retain. Screw	Carbon steel
11	Indicator Stop	Malleable iron
12	Stop Pin	Carbon steel
13	Gland Nut	Carbon steel
14	Gland	Stainless steel
15	Wrench	Malleable iron
16	Wrench Extension	Carbon steel
17	Wrench Fixing Bolt	Carbon steel
18	Body Bolt	Carbon steel
19	Body Nut	Carbon steel
20	Label-Titanium	Aluminum



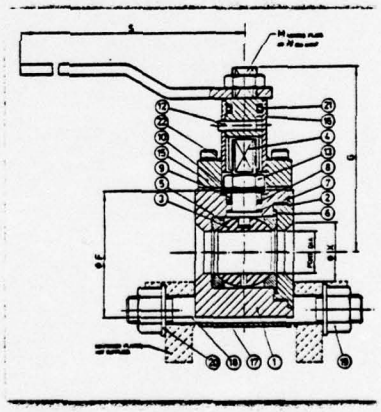


—Top Line in Inches
—Bottom Line in MM

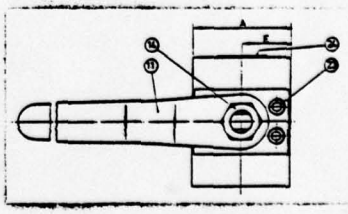
Size	Port	A	C	D	E	G	H	M	N	Q	R	S	T	X	Weight lb. (kg)
3	2.50 (63.5)	4.37 (111.0)	3.87 (98.4)	.65 (16.7)	2.01 (51.0)	5.72 (145.3)	7.30 (185.3)	.744 (18.9)	.96 (22.8)	1.75 (44.5)	3.37 (85.7)	13.78 (350.0)	3.07 ¾UNF	22.7 (78.0)	(10.3)
4	3.25 (82.6)	5.27 (134.0)	4.48 (113.9)	.66 (16.7)	2.64 (67.0)	6.34 (161.1)	7.92 (201.1)	.744 (18.9)	.90 (22.8)	1.75 (44.5)	3.37 (85.7)	21.97 (558.0)	4.01 ¾UNF	33.0 (102.0)	(15.0)
6	4.37 (111.1)	6.77 (172.0)	6.19 (157.2)	1.03 (26.2)	3.39 (86.0)	8.34 (226.2)	11.16 (283.5	1.12 (28.4)	1.39 (35.2)	2.99 (76.2)	3.99 (101.6)	33.46 (850.0)	6.02 ½UNF	57.2 (153.0)	(26.0)
8	5.67 (144.0)	9.02 (229.0)	7.32 (184.9)	1.03 (26.2)	4.53 (115.0)	9.99 (254.0)	12.26 (311.3)	1.12 (28.4)	1.39 (35.2)	2.99 (76.2)	3.99 (101.5)	33.46 (850.0)	7.99 ½UNF	112.2 (203.0)	(51.0)

½" - 2"

ITEM NO.	DESCRIPTION	MATERIAL SPECIFICATION
1	Body	Titanium 125
2	Insert	Titanium 125
3	Ball	Titanium 125
4	Stem	Titanium 125
5	Seat	PTFE Virgin
6	Insert Seal	PTFE Virgin
7	Stem Thrust Seal	PTFE 25% glass filled
8	Gland Packing	PTFE 25% glass filled
9	Gland	Titanium 125
10	Disc Spring	Stainless steel
11	Wrench	Stainless steel
12	Stop Pin	Stainless steel
13	Gland Nut	Stainless steel
14	Wrench Nut	Stainless steel
15	Extension Support	Stainless steel
16	Extension Stem	Stainless steel
17	Spacer Tube	Stainless steel
18	Body Bolt	Carbon steel
19	Body Nut	Carbon steel
20	Washer	Carbon steel
21	'O' Ring	Buna
22	Fixing Screw	Stainless steel
23	Fixing Screw	Stainless steel
24	Label-Titanium	Aluminum

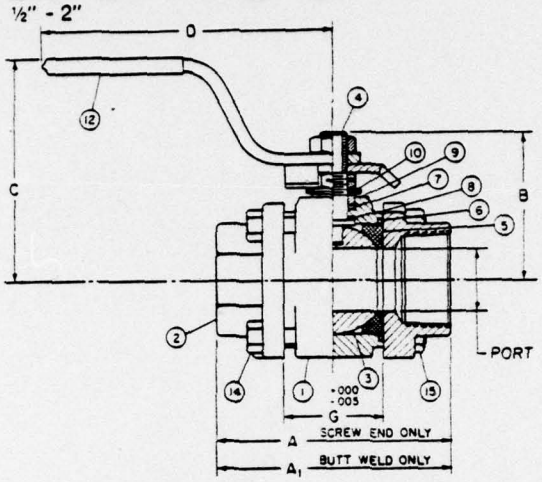


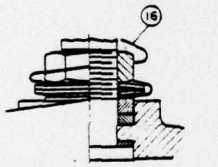
Size	Port	A	E	F	G	H	M	N	S	X	Weight lb. (kg)
½	.43 (11.0)	1.50 (38.0)	.75 (19.0)	1.87 (47.6)	2.97 (75.4)	3.07 (78.0)	.22 (5.5)	.37 (9.5)	4.25 (108.0)	.69 (17.5)	2.0 (0.9)
¾	.55 (14.0)	1.50 (38.0)	.75 (19.0)	2.0 (50.8)	3.03 (77.0)	3.14 (79.8)	.22 (5.5)	.37 (9.5)	4.25 (108.0)	.94 (23.8)	2.4 (1.1)
1	.81 20.6	1.87 (47.6)	.94 (23.8)	2.50 (63.5)	3.62 (92.0)	3.66 93.0	.30 (7.5)	.44 (11.1)	5.75 (146.0)	1.13 (28.6)	3.0 (1.4)
1½	1.25 31.8	2.24 (57.0)	1.13 (28.6)	3.37 (85.7)	4.53 (115.0)	4.59 116.5	.34 (8.7)	.56 (14.3)	7.0 (178.0)	1.38 (35.0)	4.4 (2.0)
2	1.50 38.0	2.63 (66.7)	1.31 (33.3)	4.0 (101.6)	4.72 (120.0)	4.78 121.5	.34 (8.7)	.56 (14.3)	7.0 (178.0)	1.56 (39.7)	5.3 (2.4)

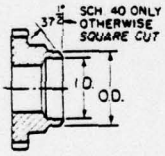


Series 400

½" - 2"







BUTT WELD
BW
SCH 5, 10, & 40

Item No.	Description	Material
1	Body	Titanium
2	Pipe End	Titanium
3	Ball	Titanium
4	Stem	Titanium
5	Seat	Polyfill, Virgin TFE
6	Body Seal	Virgin TFE
7	Stem Seal	15% G.F. TFE
8	Thrust Bearing	Polyfill
9	Follower	Titanium
10	Belleville Washer	301.S.S.
11	Stem & Handle Nut	AISI 303—Silver Plated
12	Handle w/Sleeve	ASTM A 167-70 Type 304 Vinyl Plastisol
13	Stop	304 S.S.
14	Body Bolt	304 S.S.
15	Body Nut	304 S.S.
16	Grounding Spring (opt.)	300 Series ST.STL

DIMENSIONS

inches (mm)

VALVE SIZE	A	A1	B	C	D	E	F	G	SCH. 5 OD	SCH. 5 ID	SCH. 10 OD	SCH. 10 ID	SCH. 40 OD	SCH. 40 ID	PORT
½	2.56 (65.02)	2.50 (63.50)	1.50 (38.10)	2.91 (73.91)	4.72 (119.89)	62 (15.75)	1.75 (44.45)	.813 (20.65)	.840 (21.33)	.710 (18.03)	.840 (21.33)	.672 (17.07)	.840 (21.33)	.625 (15.87)	.44 (11.18)
¾	2.79 (70.87)	2.73 (69.34)	1.62 (41.15)	3.00 (76.20)	4.72 (119.89)	.75 (19.05)	2.00 (50.80)	.969 (24.61)	1.050 (26.67)	.920 (23.36)	1.050 (26.67)	.875 (22.22)	1.050 (26.67)	.812 (20.62)	.56 (14.22)
1	3.69 (93.72)	3.62 (91.95)	2.19 (55.63)	3.50 (88.90)	6.31 (160.27)	.88 (22.35)	2.38 (60.45)	1.250 (31.75)	1.315 (33.40)	1.185 (30.10)	1.315 (33.40)	1.094 (27.79)	1.315 (33.40)	1.049 (26.64)	.81 (20.57)
1½	4.53 (115.06)	4.47 (113.54)	2.88 (73.15)	4.38 (111.25)	5.75 (146.05)	1.12 (28.45)	3.00 (76.20)	1.906 (48.41)	1.900 (48.26)	1.770 (44.96)	1.900 (48.26)	1.672 (42.47)	1.900 (48.26)	1.594 (40.49)	1.25 (31.75)
2	4.96 (126.49)	4.90 (124.46)	3.06 (77.72)	4.59 (116.59)	5.75 (146.05)	1.31 (33.27)	3.38 (85.85)	2.218 (56.34)	2.375 (60.33)	2.245 (57.02)	2.375 (60.33)	2.147 (54.53)	2.375 (60.33)	2.062 (52.37)	1.50 (38.10)

Dimensions are for layout purposes only. For tolerances, contact Worcester Controls.

How to order Worcester Ti-Miser™

Series 49

SIZES ½" - 8" **ORDERING EXAMPLE**

1½"	49	T	T	R	T	NP
Size	Style	Body/ Ends	Ball Stem/	Seat*	Seal*	Wafer Style No end connections

Materials of Construction		
	Material	**Code**
Body, End Ball, Stem	Titanium	T
Seat	Reinforced TFE	R
	TFE	T
Seal	TFE	T

Series 400

SIZES ½" - 2" **ORDERING EXAMPLE**

½"		4	T	T	P	T	SE
Size	Options	Style	Body/ Ends	Ball/ Stem	Seat*	Seal*	End Connections

Options: Blank—Hand Valve; A—Mounting Bracket; G—Grounding Spring

Materials of Construction		
	Material	**Code**
Body, End Ball, Stem	Titanium	T
Seat	TFE	T
	Reinforced TFE	R
	Polyfill Reinforced TFE	P
Seal	TFE	T
End conn. construction	Screwed end	SE
	Buttweld sched 10	BW1
	Buttweld sched 5	BW5
	Buttweld sched 40	BW4

*Alternate seat and seal materials are available. Please consult Worcester.

CAUTION: DO NOT USE on hydrochloric, sulphuric, phosphoric, oxalic, formic acid, aluminum or calcium chloride, oxygen, hydrogen peroxide or fuming nitric acid, dry chlorine gas.

WORCESTER
125 HARTWELL STREET, WEST BOYLSTON, MA 01583 617-835-6041

PRINTED IN USA 5/79 20M

SB45-1

the series 45 ball valve



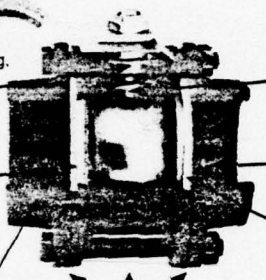
WORCESTER

T-46

The Econo-o-Miser® is "Best by Design"

Quarter-turn for ease of operation. Handle indicates direction of flow.

Easily adaptable to either pneumatic or Electric actuators for field mounting.



Unique adjustable stem sealing. Double Belleville washers compensate for wear and temperature fluctuations.

Resilient seats give bubble-tight sealing. Patented design gives low torque and reduced seat wear.

Available with variety of pipe ends: screwed, socket weld or butt weld.

Compact, safe, bottom entry adjustable stem. Cannot be removed when valve is under pressure.

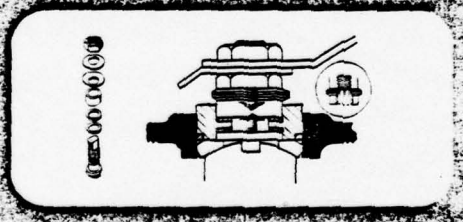
Smooth two-way flow path for maximum CV.

Separate body seals prevent atmospheric leakage.

3 piece body design. Serves as both a valve and a union.

(2½" Valve Shown)

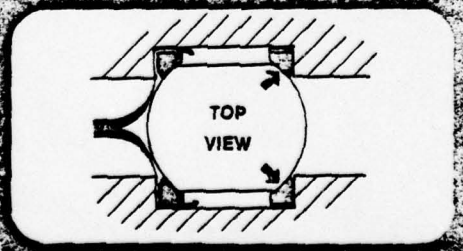
Bottom entry stem adjusts for leak-tight in-line sealing



For maximum safety, the stem is designed with a Reinforced TFE thrust-bearing, and inserted through the ball cavity until it rests against a shoulder in the valve body. A second seal, above the body shoulder, is held in place by a follower, two Belleville washers and an adjusting nut. Simple, in-line stem seal adjustments keep washers flexed, automatically compensating for normal wear as well as seal expansion and contraction from temperature fluctuations.

Standard thermal vent hole in ball relieves any thermal expansion within the cavity, when valve is open.

Patented resilient seat* seals downstream lowers torque, lasts longer



Two-way flow is regulated by downstream sealing against patented, resilient seats, resulting in bubble-tight shut-off throughout a life-time of service. Resiliency is designed-in and not dependent on resiliency of seating materials used. During each cycle, self-wiping action keeps the seat and ball clean...and the closure, leak-tight.

Patented slots in the seat relieve upstream pressure past the upstream seat, keeping it from being forced against the ball. The result? Less friction, lower operating torque, less seal wear and longer service life. Relief slots also permit higher pressure differential than possible with double-sealing valves in which there is sealing between both seats and the ball.

* Patents No. 3,930,576

Install the Econ-o-Miser® for less

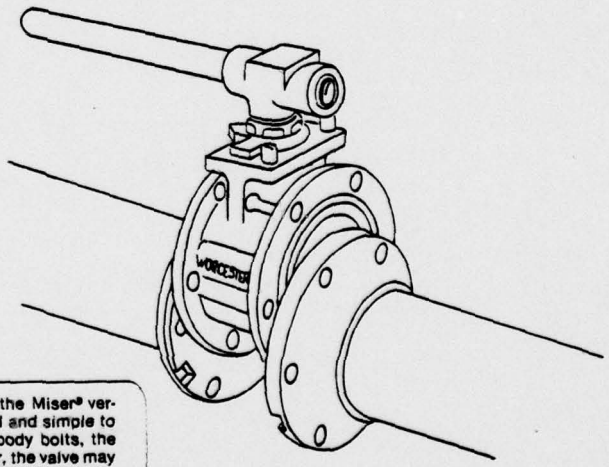
The installed cost of the Econ-o-Miser is substantially less than an average ball valve. The Econ-o-Miser is ready for installation as is. There are no additional materials required.

Standard Gate Valves: flanges, gaskets, nuts, bolts, flange make-up, bolt-up plus the weight of handling and labor make the total installed cost of a gate valve substantially higher than the Econ-o-Miser.

Standard Ball Valves: Pipe unions and labor raise the total installed cost of the average ball valve up to 20% more than the Econ-o-Miser.

The Econ-o-Miser: Installed cost is substantially less because there are no pipe unions, flanges, gaskets, nuts or bolts. Three piece construction makes the Econ-o-Miser both a valve and a union, providing fast installation and simple maintenance.

Three piece construction makes swing away possible, total entry simple.



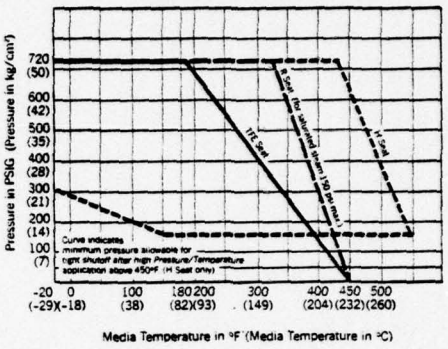
Three-piece construction makes the Miser® versatile in application, easy to install and simple to maintain. By removing all of the body bolts, the valve may be lifted out of the line or, the valve may swing out in line by removing five of the body bolts and loosening the sixth, thus easily maintaining the piping system alignment. Seats, seals and ball can all be replaced quickly and easily. Three-piece construction also means that it serves as both a valve and a union. It also is especially practical for use in welded piping systems where line breaks are required. All body bolts may be removed and the center section replaced, if necessary.

Specifications

MAXIMUM CV DATA

VALVE SIZE	MAX. CV (USGPM)
2½"	250
3"	400
4"	720
6"	1020

PRESSURE/TEMPERATURE RATING GRAPH
SEAT & SEAL MATERIALS

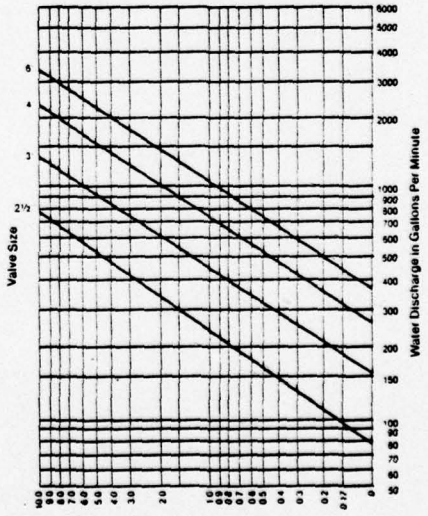


Series 45 Valves are rated to 150 psi saturated steam. For more severe applications, consult Worcester Controls.

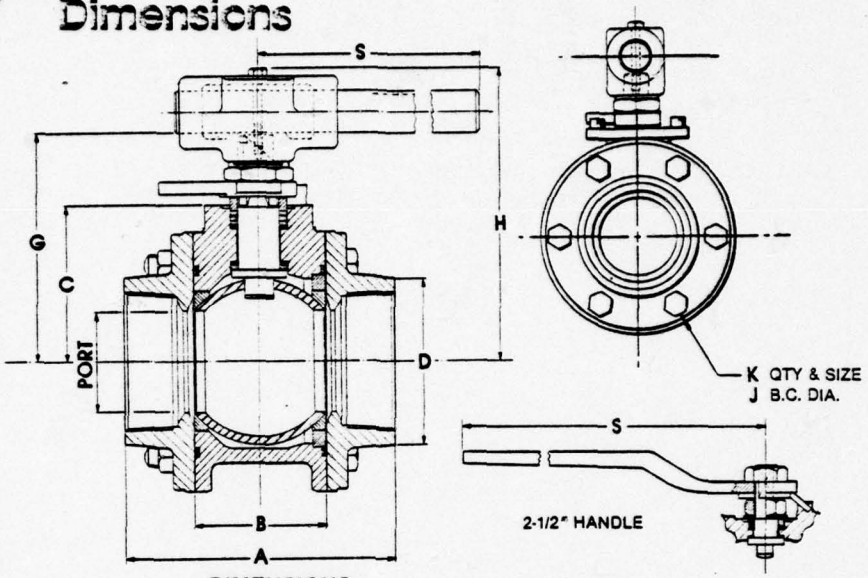
MAXIMUM BREAKAWAY TORQUE AT RATED PRESSURE

VALVE SIZE	TORQUE (IN LBS.)
2½"	800
3"	1200
4"	2000
6"	4800

HEAD LOSS/FLOW RATING GRAPH
Head Loss in PSI



Dimensions



DIMENSIONS

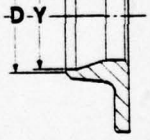
Top Line In Inches (Bottom Line In MM)

Valve Size	Port	A	B	C	G	H	S
2½	2.00 (50.8)	5.62 (142.8)	2.63 (66.7)	— —	3.46 (88.0)	3.72 (94.5)	7.00 (178.0)
3	2.50 (63.5)	6.65 (169.0)	3.28 (83.3)	3.87 (98.4)	5.72 (145.3)	7.30 (185.3)	13.78 (350.0)
4	3.25 (82.6)	8.41 (213.6)	4.28 (108.8)	4.49 (14.0)	6.34 (161.1)	7.92 (201.1)	21.97 (558.0)
6	4.37 (111.1)	11.75 (298.5)	5.75 (146.0)	6.19 (157.2)	8.91 (226.2)	11.16 (283.5)	33.46 (850.0)

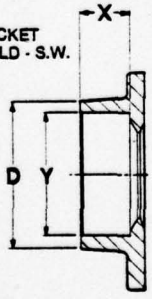
WEIGHT

Size	Complete with Pipe Ends	Center Section Only
2½	12.00 (5.45)	9.50 (4.27)
3	30.00 (13.60)	18.50 (8.33)
4	50.26 (22.80)	34.00 (15.30)
6	80.24 (36.40)	68.00 (30.80)

BUTT WELD - B.W.



SOCKET WELD - S.W.



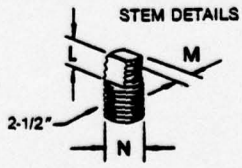
END CONNECTIONS

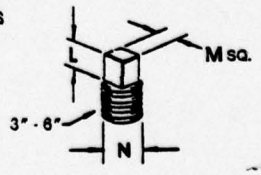
Valve Size	D SE - SW	D BW	X SW	X BW40	X BW10	Y SW	Y BW40	Y BW10
2½	3.44 (87.3)	2.87 (73.0)	1.18 (30.0)	2.60 (66.0)	— —	2.90 (73.7)	2.47 (62.7)	2.77 (70.3)
3	4.09 (104.0)	3.50 (88.9)	1.30 (33.0)	3.19 (81.0)	3.39 (86.0)	3.53 (89.6)	3.07 (77.9)	3.25 (82.5)
4	5.19 (131.8)	4.50 (114.3)	1.57 (40.0)	4.17 (106.0)	4.41 (112.0)	4.53 (115.0)	4.02 (102.0)	4.25 (108.0)
6	7.46 (189.9)	7.44 (188.9)	2.01 (51.0)	6.22 (158.0)	— —	6.85 (168.9)	6.06 (154.0)	6.36 (161.5)

STEM DIMENSIONS

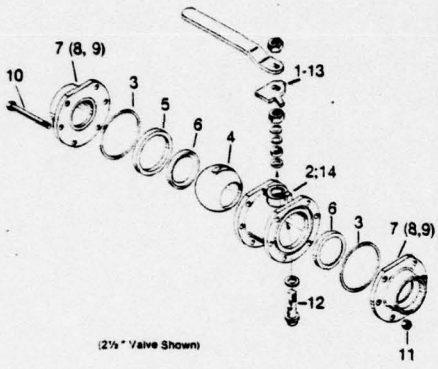
Valve Size	L	M	N
2½	.75 (19.0)	—	—
3	.56 (16.7)	.74 (18.9)	.90 (22.8)
4	.56 (16.7)	.74 (18.9)	.90 (22.8)
6	1.03 (26.2)	1.12 (28.4)	1.39 (35.2)

STEM DETAILS





Parts Identification and Material Specifications



(2½ " Valve Shown)

NAME	NO. PER VALVE	MATERIAL	REMARKS
No. 1:			
Stem Assembly—2½			
Handle	1	Carbon Steel	Cadmium plated
Stop	1	Carbon Steel	Cadmium plated
Belleville Washer	2	Carbon Steel	Cadmium plated
Handle Nut	1	Carbon Steel	Cadmium plated
Stem Seal	2	P.T.F.E. 15% G.F.	Glass Filled
Follower	1	416 S.S.	
Retaining Nut	1	Carbon Steel	Cadmium plated
Thrust Bearing	1	P.T.F.E. 25% G.F.	Glass Filled
No. 14 & 2: Body	1	Carbon Steel, 316 Stainless Steel	
No. 3: Body Seal	2	PTFE	
No. 4: Ball	1	*316 Stainless Steel*	
No. 5: Seat Retainer	1	Carbon Steel, 316 Stainless Steel	
No. 6: Seat	2	PTFE, 15% Glass filled PTFE, VX1	
No. 7: Pipe End B.W.	2	Carbon Steel, 316 Stainless Steel	
No. 8: Pipe End S.W.	2	Carbon Steel, 316 Stainless Steel	
No. 9: Pipe End SCR	2	Carbon Steel, 316 Stainless Steel	
No. 10: Body Bolt 2½ " & 3"	6	Grade B-5 Carbon Steel	
4" & 6"	8		
No. 11: Body Nut 2½ " & 3"	6	ASTM A194 GR 2H	
4" & 6"	8		
No. 12: Stem	1	316 Stainless Steel	
No. 13:			
Stem Assembly 3, 4 & 6			
Handle	1	Mal. Iron	
Stop	1	Mal. Iron	
Stop screws	2	Carbon Steel	
Stem Seal	3	P.T.F.E. 15%	Glass Filled
Retaining Nut	1	Carbon Steel	Cadmium plated
Follower	1	416 S.S.	
Location Washer	2	416 S.S.	ST. ST.
Thrust Bearing	1	P.T.F.E. 25%	Glass Filled

How to Order Series 45 Ball Valves

Ordering Example
Sizes 2½ " - 6"

4"	45	6	6	R	T	SE
SIZE	STYLE	BODY PIPE END	BALL, STEM	SEATS	SEALS	TYPE OF ENDS

Part	Material	Code
Body, Pipe Ends	Carbon Steel	4
	316 Stainless Steel	6
Ball, Stem	316 Stainless Steel	6
Seats, Seals	TFE	T
	Reinforced TFE	R
Construction of Ends		
Screw End		SE
Socket Weld		SW
Buttweld, Schedule 40		BW4
Buttweld, Schedule 10		BW1

Full port valves are available. See PB461 for further information.

WORCESTER
125 HARTWELL STREET
WEST BOYLSTON, MASSACHUSETTS 01583, PHONE (617) 835-6041

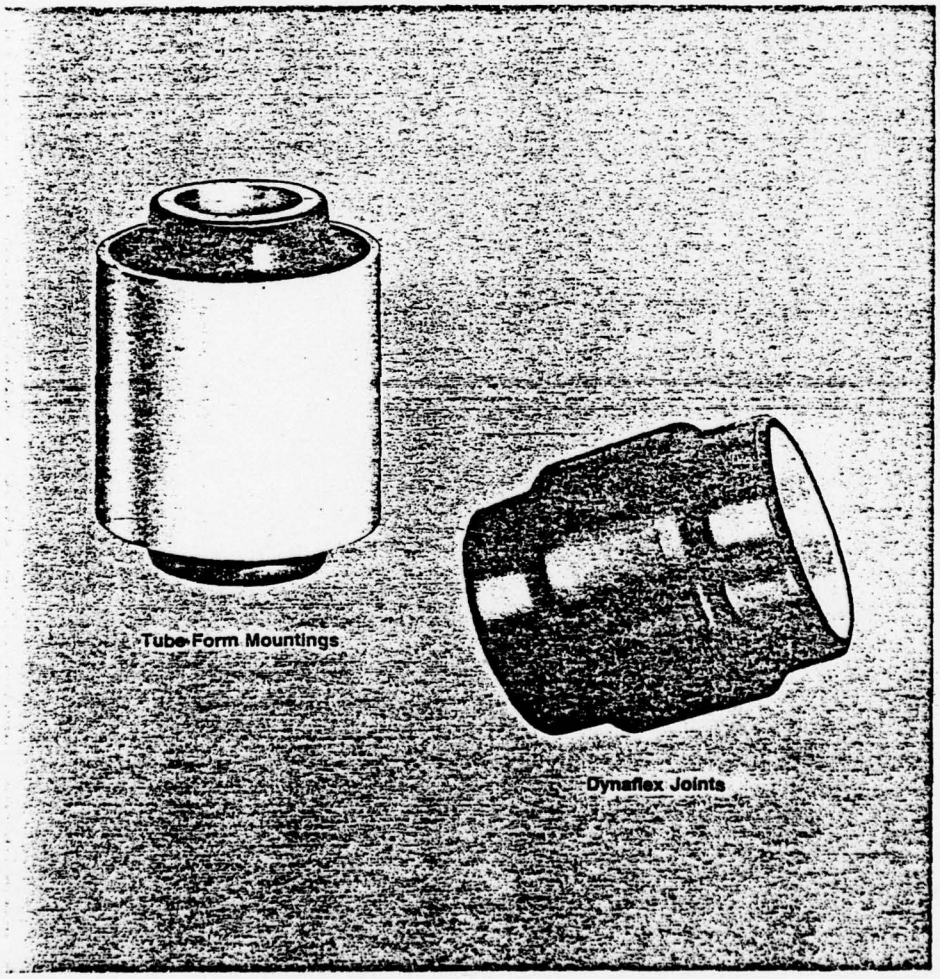
Printed in U.S.A. 20M 979

W. R. Richards

Lord Kinematics

Bulletin No. 713

Tube Form Mountings and Dynaflex® Joints



guide to application of Tube Form Mountings and Dynaflex Joints

Although similar in appearance after installation, Tube Form Mountings (Full Bonded) and Dynaflex Joints (Center Bonded) are designed for entirely different applications. In selecting these units for a particular application, several basic factors must be considered:

GENERAL USE: *Tube Form Mountings provide* vibration isolation, shock and noise attenuation in varied applications. Tube Forms provide maximum vibration isolation when installed to carry the load in the axial (shear) direction. *Dynaflex Joints* are used in pivot joints where the elimination of wear and lubrication, absorption of shock and attenuation of noise are prime operating requirements.

INSTALLATION: *Tube Form Mountings are normally* loaded axially, the direction of the softest spring rate. They have a high radial stiffness for good stability. They are compact and provide maximum capacity for a given size part. *Dynaflex Joints* are loaded radially, and utilize the soft torsional spring rate to provide freedom in rotation. They also provide high radial restraint to maintain alignment between joined parts. As pivots, they absorb shock, reduce noise, require no maintenance or lubrication and have excellent wearing properties.

CONSTRUCTION: *Tube Form Mountings* consist of two concentric tubular metal members permanently joined by an elastomer. *Dynaflex Joints consist of* an elastomer bonded to an inner metal member only.

CAPACITY: *Tube Form Mountings* are available with axial load capacities ranging from ½ to 1,500 pounds per mounting. Deflections range from 0.040" to 0.250" at rated load. *Dynaflex Joints* are produced in a wide variety of sizes with radial load capacities ranging from 10 pounds to as high as 100,000 pounds depending upon type and severity *of service.*

LORD TUBE FORM MOUNTINGS (Full Bonded)

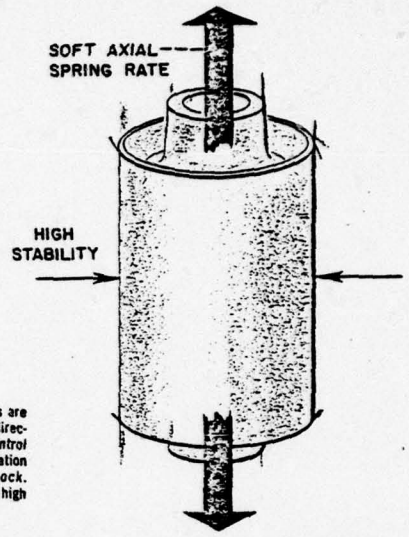


Figure 1.
Tube Form Mountings are softest in the axial direction for efficient control of continuous vibration and occasional shock. They also provide high radial restraint.

LORD DYNAFLEX JOINTS (Center Bonded)

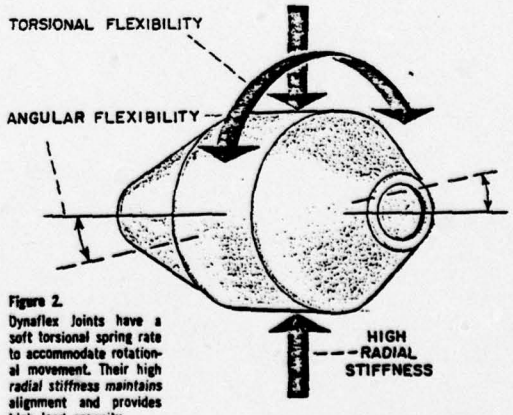
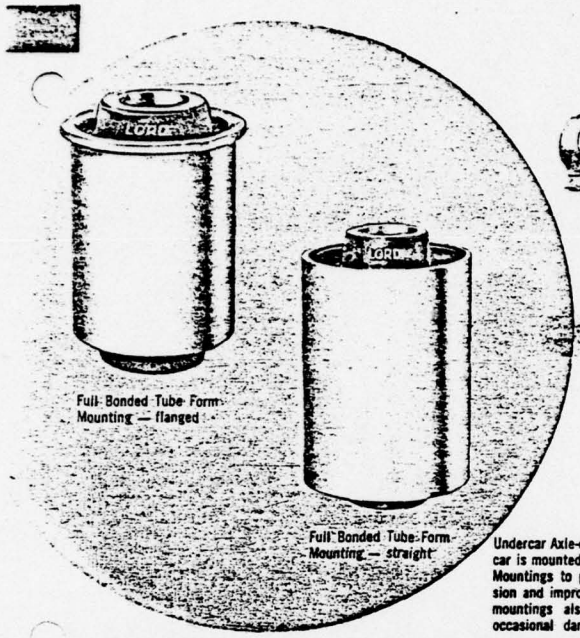


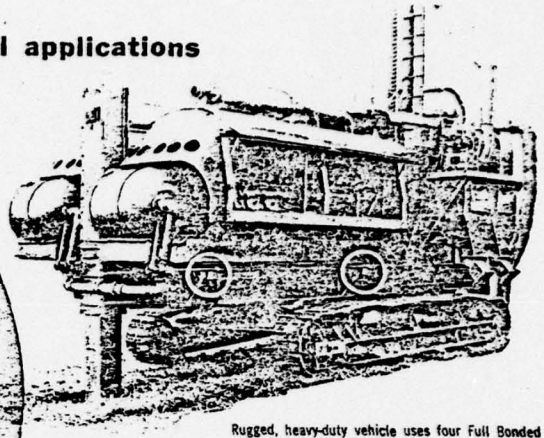
Figure 2.
Dynaflex Joints have a soft torsional spring rate to accommodate rotational movement. Their high radial stiffness maintains alignment and provides high load capacity.

typical applications

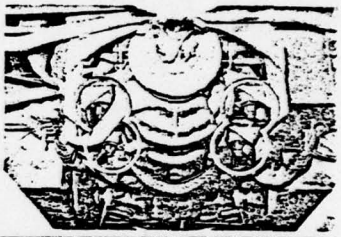


Full Bonded Tube Form Mounting — flanged

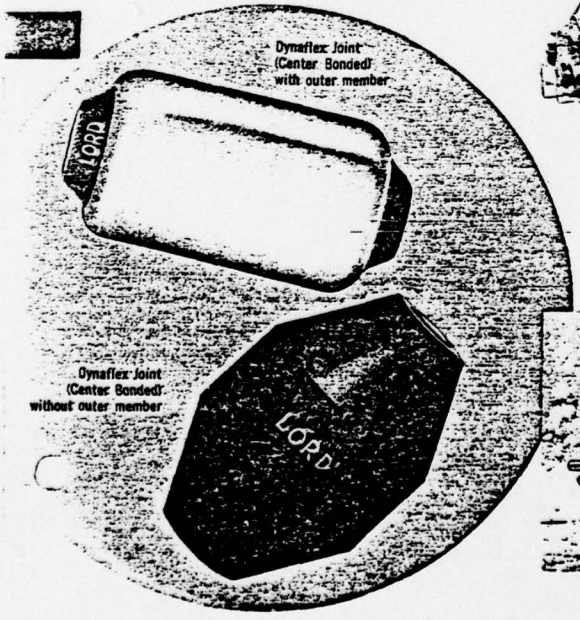
Full Bonded Tube Form Mounting — straight



Rugged, heavy-duty vehicle uses four Full Bonded Tube Form Mountings to protect engines from severe shock and vibration of quarrying operations.

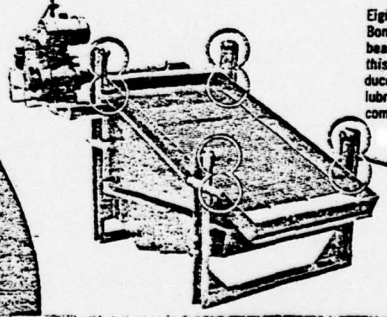


Undercar Axle-driven Generator on railroad car is mounted on Full Bonded Tube Form Mountings to prevent vibration transmission and improve passenger comfort. The mountings also protect the unit from occasional damaging shock.

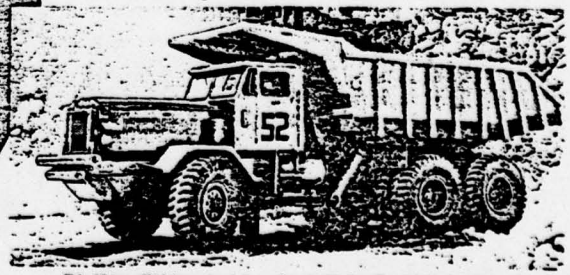


Dynaflex Joint (Center Bonded) with outer member

Dynaflex Joint (Center Bonded) without outer member

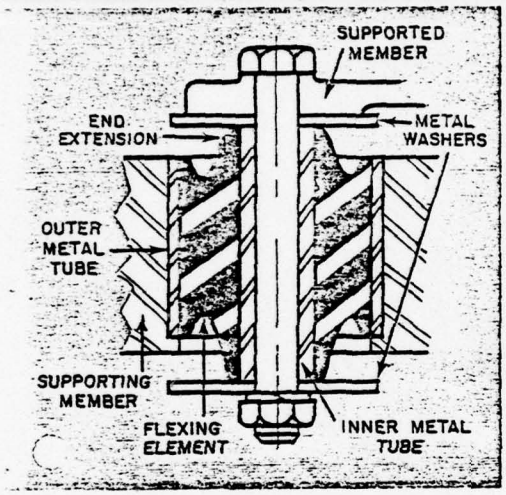


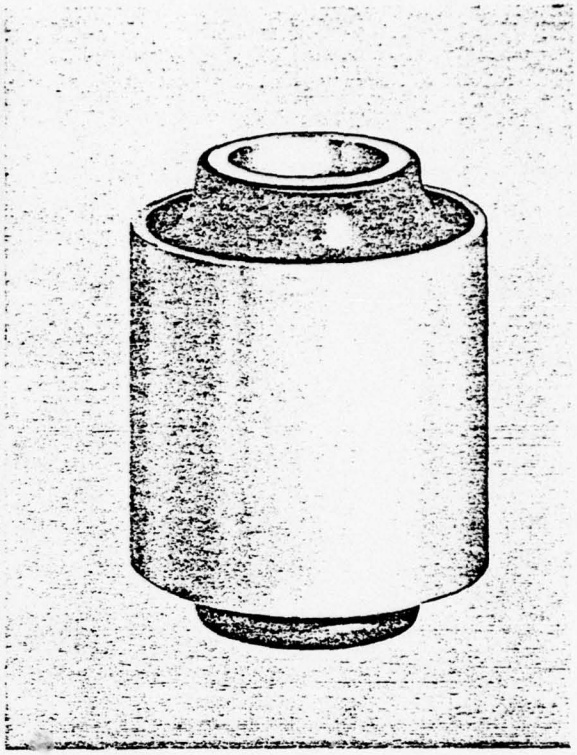
Eight Dynaflex Joints (Center Bonded) serve as resilient bearings at pivot points on this shake screen. They reduce maintenance, never need lubrication and far outlast comparable all-metal units.



This 55-ton off-highway truck is equipped with Dynaflex Joints at torque rod ends to improve spring suspension performance and reduce maintenance. The joints withstand radial driving forces sometimes exceeding 12 tons.

FULL BONDED TUBE FORM MOUNTINGS





. . . for isolation of steady-state vibration and protection from infrequent shock

features:

excellent stability — *Lateral movement* limited by radial stiffness 4 to 12 times greater than axial stiffness, depending on design.

proven design — Optimum vibration isolation characteristics provided by stressing of *flexing element* in shear for maximum deflection.

safety — High ratio of bond strength to working stress provides a reliable safety factor. Snubbing washers, where required, provide the additional feature of interlocked metal parts.

easy installation — Mountings can be quickly pressed or clamped into place.



extra long life — Flexing element contour is designed to provide uniform stress distribution. High-strength bond and specially compounded elastomers result in maximum service life.

description: Full Bonded Tube Form Mountings consist of two concentric tubular members joined by an elastomer which is permanently bonded to both outer and inner members. This resilient element provides low axial stiffness with high radial restraint to insure a stable installation. Clearance for axial movement is provided by making the inner member longer than the outer member. The elastomeric section is contoured at the ends to eliminate stress concentrations.

Full Bonded Tube Form Mountings can be made in a variety of metals and elastomers to meet environmental conditions. Axial load ratings available in standard mountings range from ½ to 1500 pounds per mounting. Requests for special designs or larger capacities should be directed to Lordco Supply, Erie, Pa., 16505.

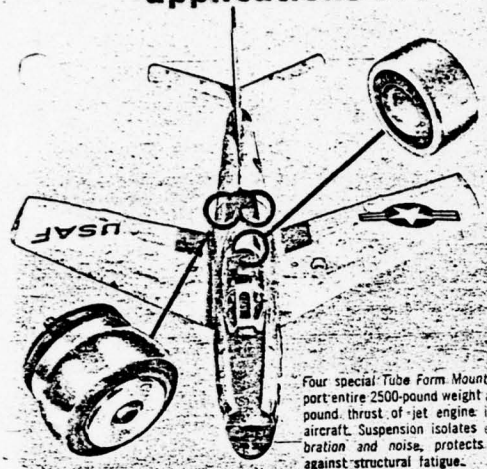
installation: Full Bonded Tube Form Mountings are securely installed by pressing or clamping the outer member into a socket in the supporting structure. A shoulder in the socket properly positions the mounting. Flanged type mountings eliminate the need for a shoulder. The supported units are bolted to the inner tubular member.

Where necessary, functions of inner and outer members may be reversed, the inner attaching to the supporting structure and the outer to the supported unit.

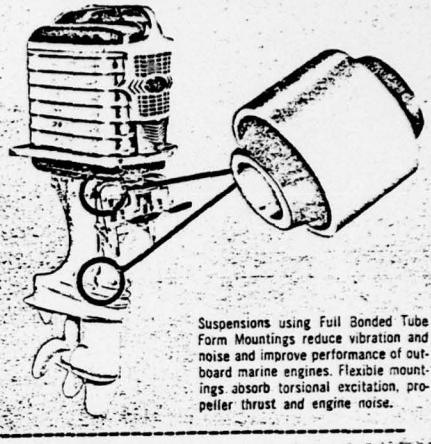
Metal washers, where required, may be installed at both ends of the inner member to provide interlocking of metal parts.

applications . . .

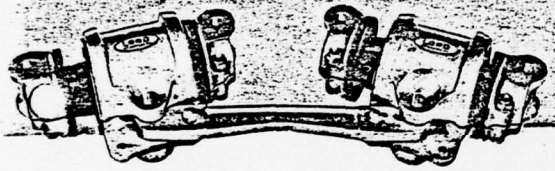
Full Bonded Tube Form Mountings function best in center-of-gravity suspensions. They are normally loaded axially to support light to medium-weight equipment. Their use results in (1) efficient isolation of steady-state vibration, (2) protection from occasional shock and (3) excellent stability.



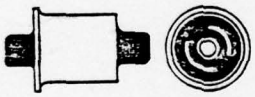
Four special Tube Form Mountings support entire 2500-pound weight and 7200-pound thrust of jet engine in fighter aircraft. Suspension isolates engine vibration and noise, protects airframe against structural fatigue.

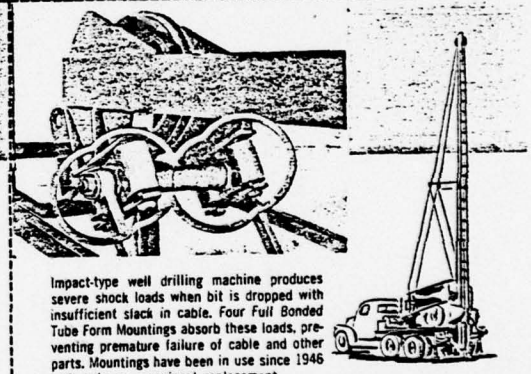


Suspensions using Full Bonded Tube Form Mountings reduce vibration and noise and improve performance of outboard marine engines. Flexible mountings absorb torsional excitation, propeller thrust and engine noise.

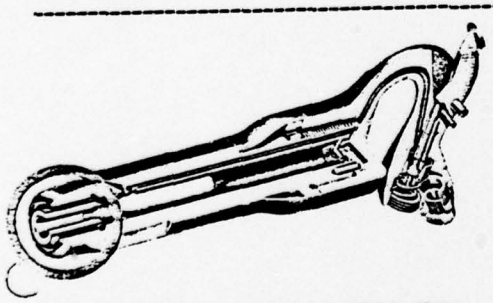


The Lord RC-27 Dynafocal Suspension system for radial aircraft engines uses six or eight special Tube Form Mountings linked in pairs as shown. Unusual feature is the cored flexing element which provides controlled stiffness characteristics.

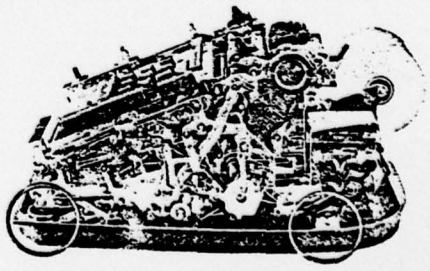




Impact-type well drilling machine produces severe shock loads when bit is dropped with insufficient slack in cable. Four Full Bonded Tube Form Mountings absorb these loads, preventing premature failure of cable and other parts. Mountings have been in use since 1946 with only an occasional replacement.



Tube Form Mounting absorbs tool shock on pneumatic chipping hammer providing greater operator comfort, quieter performance, even flow of cutting power and decrease in maintenance.

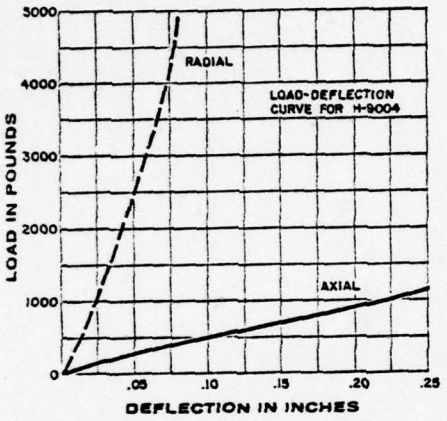


Vibration and noise of this calculating machine are isolated by four Full Bonded Tube Form Mountings which suspend the chassis above the base tray.

FULL BONDED TUBE FORM MOUNTINGS

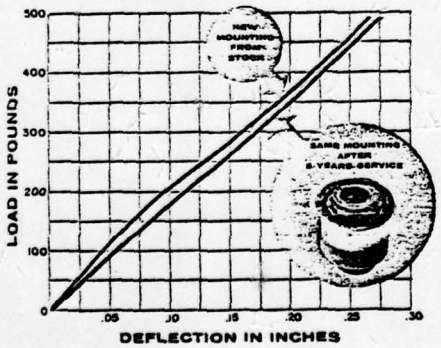
• performance

soft axially – stiff radially



Axial softness of Full Bonded Tube Form Mountings provides excellent attenuation of vibration, shock and noise. Optimum performance is realized where *disturbing motion is predominantly uni-directional.* **Radial stiffness** assures high radial stability and alignment accuracy. **Rubber-in-shear design** provides cocking softness, maximum capacity for given size and simplified installation.

long life under rugged conditions



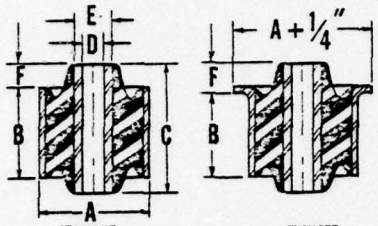
Long-wearing properties are indicated by this Full Bonded Tube Form Mounting, installed underneath a railroad car to support a motor-generator set. *In service for five years, it was exposed to extremes* of temperature, weather and track grime. Still in good operating condition, the mounting had retained virtually its original spring rate as shown above. Destruction test required 10.5 times rated load to cause failure. Externally, mounting was weather-beaten, *but otherwise unaffected.*

• specifications

tolerances — request individual part drawing

LOAD RATING (pounds)	DEFLECTION (inches)	PART NUMBER	
		STRAIGHT	FLANGED
½	.062	J-828-1#A	—
1	.062	J-828-1#1	—
1½	.062	J-828-1#1A	—
2	.062	J-828-1#2	—
4	.062	J-828-1#4	—
7	.062	J-828-1#7	—
10	.062	J-829-1-10	—
23	.065	H-1001	H-1001-1
30	.065	H-1002	H-1002-1
60	.065	H-1003	H-1003-1
70	.068	H-3002	H-3002-1
88	.078	H-5019	H-5019-1
90	.065	H-1004	H-1004-1
140	.068	H-3004	H-3004-1
150	.200	—	J-4363-1
175	.078	H-5006	H-5006-1
180	.068	H-3006	H-3006-1
225	.078	H-5017	H-5017-2
230	.092	H-9001	H-9001-1
250	.200	—	J-4363-3
275	.078	H-5013	H-5013-5
325	.078	H-5020	H-5020-1
350	.092	H-9002	H-9002-1
365	.190	—	J-5417-1
438	.092	H-9003	H-9003-1
450	.108	HS-3001	HS-3001-1
510	.092	H-9004	H-9004-1
550	.108	HS-3002	HS-3002-1
590	.092	H-9005	H-9005-1
610	.188	J-2228-1	—
650	.108	HS-3003	HS-3003-1
670	.092	H-9006	H-9006-1
690	.123	HS-7001	HS-7001-1
750	.108	HS-3004	HS-3004-1
755	.125	—	J-2430-1
800	.188	—	J-4229-1
810	.123	HS-7002	HS-7002-1
850	.108	HS-3005	HS-3005-1
900	.188	J-2228-14	—
935	.123	HS-7003	HS-7003-1
950	.108	HS-3006	HS-3006-1
1000	.188	—	J-4229-3
1080	.123	HS-7004	HS-7004-1
1200	.123	HS-7005	HS-7005-1
1325	.123	HS-7006	HS-7006-1
1450	.123	HS-7007	HS-7007-1
1880	.194	SK-1715-0	—
2150	.342	—	*J-3050-1
3080	.342	—	*J-3050-4

*O.D. of flange is .38 greater than "A"



A**	B	C	D	E	F
.750	.156	.375	.166	.25	.11
.750	.156	.375	.166	.25	.11
.750	.156	.375	.166	.25	.11
.750	.156	.375	.166	.25	.11
.750	.156	.375	.166	.25	.11
.750	.156	.375	.166	.25	.11
1.000	.188	.563	.194	.44	.19
1.000	.375	.875	.257	.44	.25
1.000	.500	1.000	.257	.44	.25
1.000	1.000	1.500	.257	.44	.25
1.250	.500	1.125	.453	.69	.31
1.500	.500	1.125	.64	.88	.31
1.000	1.500	2.000	.257	.44	.25
1.250	1.000	1.625	.453	.69	.31
2.010/1.998	1.00	2.00	.52	.75	.62
1.500	1.000	1.625	.64	.88	.31
1.250	1.500	2.125	.453	.69	.31
1.500	1.500	2.125	.64	.88	.31
2.010/1.998	1.000	1.750	1.02	1.25	.38
010/1.998	2.00	3.00	.52	.75	.62
1.500	2.000	2.625	.64	.88	.31
1.500	2.500	3.125	.64	.88	.31
2.010/1.998	1.500	2.250	1.02	1.25	.38
2.510/2.498	1.50	2.595	.77	1.12	.50
2.010/1.998	2.000	2.750	1.02	1.25	.38
2.510/2.498	1.500	2.250	1.02	1.62	.38
2.010/1.998	2.500	3.250	1.02	1.25	.38
2.510/2.498	2.000	2.750	1.02	1.62	.38
2.010/1.998	3.000	3.750	1.02	1.25	.38
3.002/3.000	2.50	3.75	1.02	1.50	.88
2.510/2.498	2.500	3.250	1.02	1.62	.38
2.010/1.998	3.500	4.250	1.02	1.25	.38
3.005	2.000	2.750	1.02	2.00	.38
2.510/2.498	3.000	3.750	1.02	1.62	.38
2.495/2.493	3.50	4.38	.77	1.38	.56
3.002/3.000	3.00	4.25	1.02	1.50	.88
3.005	2.500	3.250	1.02	2.00	.38
2.510/2.498	3.500	4.250	1.02	1.62	.38
3.002/3.000	3.50	4.75	1.02	1.50	.88
3.005	3.000	3.750	1.02	2.00	.38
2.510/2.498	4.000	4.750	1.02	1.62	.38
3.002/3.000	4.00	5.25	1.02	1.50	.88
3.005	3.500	4.250	1.02	2.00	.38
3.005	4.000	4.750	1.02	2.00	.38
3.005	4.500	5.250	1.02	2.00	.38
3.005	5.000	5.750	1.02	2.00	.38
5.455/5.445	3.00	3.75	1.02	4.50	.38
3.995/3.992	5.00	7.50	1.02	2.12	.81
3.995/3.992	5.00	7.50	1.02	2.12	.81

**Allowable limits are +.005 and —.002 unless otherwise noted for "A" only.

• selection

In choosing Full Bonded Tube Form Mountings for a particular application, the following procedure should be used:

(1) Determine the static load (weight) to be supported by each mounting.

(2) From the table, select a mounting with suitable load rating and deflection characteristics. For intermediate loads, select a mounting with the next higher load rating.

(3) Check dimensions of the mounting selected to assure that it will fit space.

(4) From table, determine the correct part number for the mounting selected. Be sure to include the complete part number.

Where dimensions do not conform with suitable load rating, and for special designs, check with Lordco Supply.

• installation

Location: Maximum vibration protection and stability are obtained by using center-of-gravity suspensions — with the mountings located in a plane which passes through the c.g. of the suspended object. Minor deviations will not appreciably affect operation. When mountings cannot be so located, consult Lordco Supply.

Installation: *Full Bonded Tube Form Mountings are generally installed by pressing or clamping the outer member into a socket bored .001" to .003" under the minimum outside diameter of the mounting.* Use of a flanged outer member eliminates need for machining a shoulder in the socket for proper positioning.

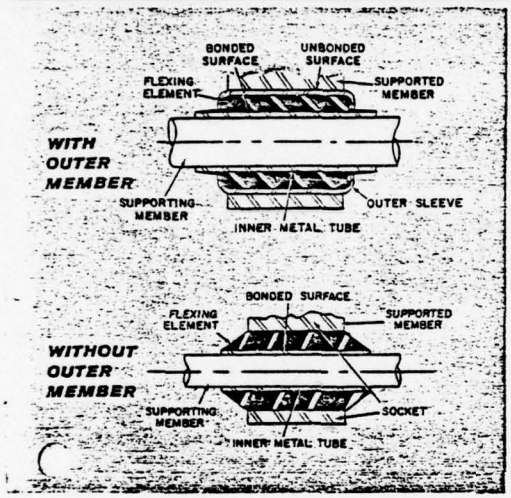
The mounted unit must be freely supported by the mountings to obtain good vibration isolation. This requires adequate clearance around the unit and freedom of motion for any connections to the unit.

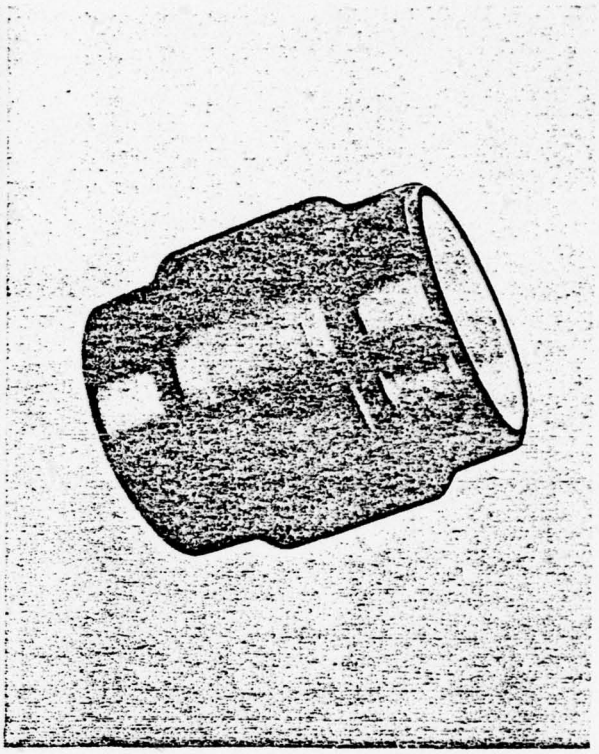
specifications for Lord Full Bonded Tube Form Mountings

standard: Metal parts are low-carbon steel tubing or bar. Flexing elements are specially compounded elastomers. Entire mounting is coated with specially prepared rust preventative for protection during shipment or storage.

specials: Included are special materials, threaded and machined outer members and tapped or reamed inner members. Painting or lacquering as specified. For special shapes, sizes and stiffness ratings and non-standard elements, contact Lordco Supply.

DYNAFLEX™ JOINTS
(CENTER-BONDED)





. . . used at pivot points to provide controlled flexibility between connected parts

features:

economical — simplified design . . . faster installation and positioning . . . less rigid *tolerances . . . fewer assembly problems . . .* long life — outlasts comparable metal parts.

wear-free — no metal-to-metal contact . . . absorption of shock and vibration assures a long service life.

lubrication-free — maintenance is virtually eliminated.

rugged — specially compounded elastomers and bonded construction withstand high static and shock loads.

positive positioning — high radial stiffness assures accurate alignment of parts.

adaptable — easy to install — readily fits space requirements of new or existing *equipment.*

description: Lord Dynaflex Joints consist of an elastomeric element permanently bonded to a tubular inner member. Bonding increases radial capacity, often to as much as twice that of an unbonded assembly. It also increases radial stiffness to maintain proper alignment between connected parts. The flexing element is softest torsionally to provide freedom in one or more rotational directions.

Two types of Dynaflex Joints are available: (1) with an outer sleeve for installation by clamping or press-fitting and (2) without an outer sleeve for installation by compressing directly into a socket.

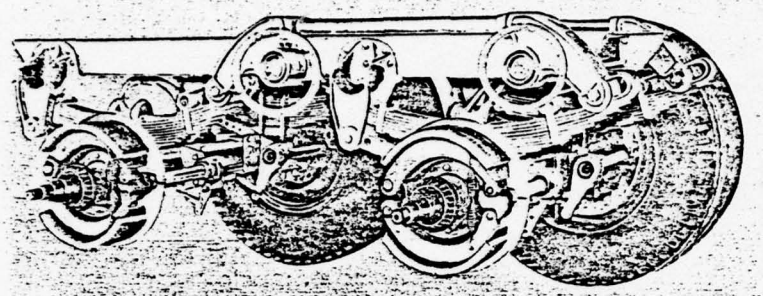
Sizes are available with radial load ratings from 10 pounds to 100,0 pounds capacity.

installation: Dynaflex Joints with an outer sleeve are installed in a socket in the supported element by clamping or press-fitting. Dynaflex Joints without an outer sleeve are compressed and press-fitted into a socket. This latter type is more economical and allows wider tolerances in cast or machined sockets.

The inner member of a Dynaflex Joint is normally attached by clamping or bolting the extended ends of the inner member to a mounting bracket. Attachment may also be accomplished by press-fitting a shaft in the *inner member.*

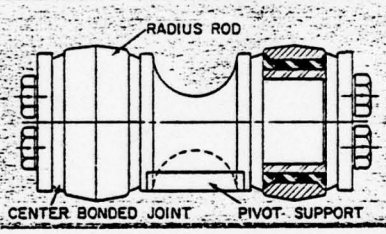
applications . . .

Dynaflex Joints have been successfully used as resilient pivot joints on heavy-duty equipment to accommodate large relative motion. They are not intended for use as torsion springs where slippage due to extreme rotational motion will occur.

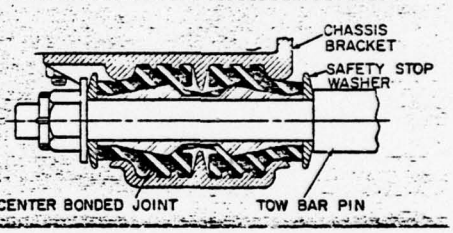




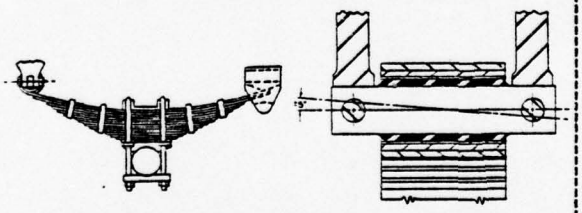
Eight Dynaflex Joints absorb shock and eliminate damaging friction on the load distributing mechanism of this trailer tandem. No lubrication is required; operating wear and maintenance costs are negligible.



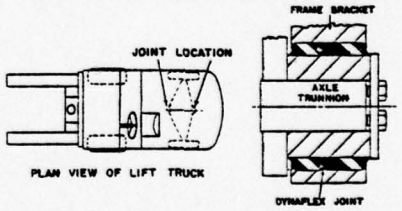
Terrific shocks and jolts of off-the-road equipment are accommodated by Dynaflex Joints installed at the torque rod ends of the suspension system. Wear is reduced, lubrication eliminated.



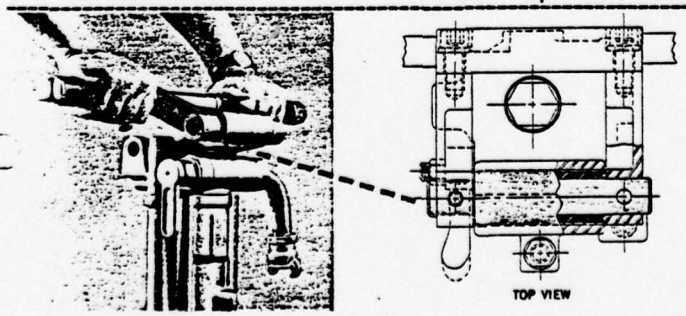
Dynaflex Joints are used in trailer hitch joints to absorb road shock, provide a more secure trailer hitch and improve driver comfort.



Trailer Leaf Spring Eye is equipped with Dynaflex Joint to eliminate wear and lubrication. Unit withstands 4500-pound static radial load and outlasts similar metal units.



Dynaflex Joint serves as torsion joint on rear steering axle of industrial lift truck. Unit eliminates wear and lubrication, withstands high radial shock loads, 3000-pound static radial load and ±15° torsional deflection.

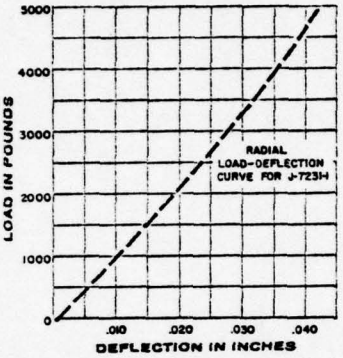


Special Dynaflex Joint acts as cushion between handle and main part of rock drill, absorbs 55% of tool shock before it can reach operator.

DYNAFLEX® JOINTS (Center Bonded)

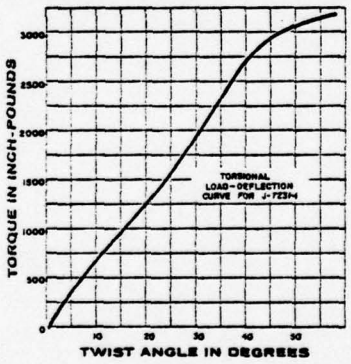
performance

excellent radial stability



High radial stiffness of Dynaflex Joints provides excellent stability and capacity for extreme static and dynamic loads. Design assures economy through low unit cost, ease of installation and no need for lubrication.

high torsional flexibility



Torsional softness or "wind-up" permits Dynaflex Joints to accommodate relative motion. Angular deflection or "cocking" can also be provided. Elimination of metal rubbing against metal prevents wear.

specifications

standard: Metal parts are low-carbon steel tubing or bar. Flexing elements are specially compounded elastomers. Entire mounting is coated with specially prepared rust preventative for protection during shipment or storage.

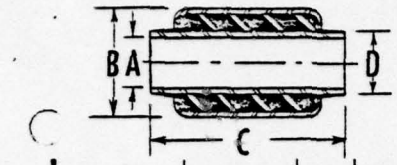
specials: Tapped or reamed inner members. For special shapes, sizes and stiffness ratings and non-standard elements, contact Lordco Supply.

Dynaflex Joints with outer member

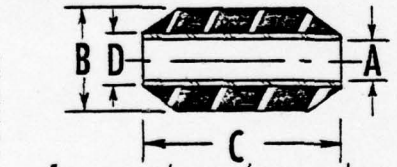
CAPACITY INDEX	PART NO.	RECOMMENDED SOCKET DIMENSIONS	
		DIAMETER	LENGTH
.13	J-5187-8	.997/.995	.62
.217	J-5990-2	.747/.745	1.00
.217	*J-5990-5	.744/.742	1.00
.281	J-5990-1	.747/.745	1.19
.313	J-5187-2	.997/.995	1.12
.45	J-3830-13	1.249/1.247	.88
1.51	*J-5385-1	1.751/1.749	2.00
2.24	*J-5384-1	2.250/2.248	2.50
4.94	J-5971-1	4.124/4.122	2.25
6.45	J-6729-2	1.997/1.995	4.00
9.4	J-6740-3	3.232/3.230	4.00
12.3	J-6145-1	4.499/4.497	4.00

Dynaflex Joints without outer member

CAPACITY INDEX	PART NO.	RECOMMENDED SOCKET DIMENSIONS	
		DIAMETER	LENGTH
.217	J-6344-2	.652/.640	1.00
.313	J-6346-2	.910/.900	1.25
.383	J-2005-2	.66	1.00
.45	J-3830-6	1.07/1.06	.88
.97	J-4705-2	1.29/1.28	1.44
1.19	J-6424-1	1.38/1.37	1.47
1.45	J-6310-1	1.72	1.56
1.51	J-5385	1.60/1.57	2.12
2.02	J-5950	2.22	1.88
2.69	J-5384	2.02/1.98	2.75
2.95	J-7121-2	1.75	2.75
3.00	J-7231-1	2.44	1.81
3.18	J-5506	2.75	2.25
4.18	J-5807-1	2.31	3.00
4.94	J-5971	3.70	2.25
6.45	J-6729	1.75	4.00
12.3	J-6145	4.00	4.00
24.5	J-7069	5.25	8.00



A	B	C	D
.257	1.005/.998	1.00	.44
.255/.250	.755/.748	1.25	.31
.255/.250	.7465/.7450	1.25	.31
.255/.250	.755/.748	1.44	.31
.257	1.005/.998	1.50	.44
.521/.511	1.255/1.250	1.00	.75
.4415/.4375	1.7535/1.7521	2.62	1.00
.4415/.4375	2.2529/2.2515	3.25	1.25
1.505/1.500	4.140/4.125	2.50	3.00
1.132/1.126	2.010/1.998	4.25	1.31
1.50	3.2335/3.2325	7.50	2.37
2.015/2.001	4.515/4.500	6.00	3.25



A	B	C	D
.255/.250	.73	1.25	.31
.257	1.00	1.50	.44
.312	.750	1.067/1.062	.44
.521/.513	1.12	1.00	.75
.641	1.37	1.625	.88
.628/.625	1.45	1.53	1.00
1.006/1.001	1.84	1.69	1.25
.4415/.4375	1.75	2.62	1.00
1.319/1.313	2.39	2.24	1.50
.4415/.4375	2.18	3.25	1.25
1.006/1.000	1.935	2.99	1.19
1.453	2.625	1.94	2.00
1.361/1.359	2.97	2.75	2.00
1.252/1.249	2.47	3.377/3.373	1.62
1.505/1.500	3.93	2.50	3.00
1.132/1.126	1.86	4.25	1.31
2.015/2.000	4.185	6.00	3.25
3.008/3.003	5.55	8.753/8.748	3.50

• selection

Factors which determine the selection of a Dynaflex Joint are (1) type and magnitude of load, (2) type of service and (3) frequency and magnitude of angular motion.

First determine the amount of static loading at the installation point. Then determine the conditions under which the joint will operate. The following should be used as a guide to type of service:

Type "A" — Extreme conditions (Reversing dynamic load or distortion at high frequency — over 600 cpm)

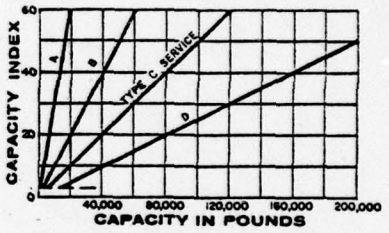
Type "B" — Average conditions (Constant radial load. Intermittent shock)

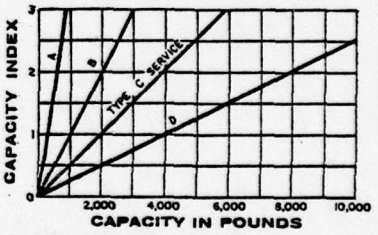
Type "C" — Moderate conditions (No static load. Occasional short duration loads)

Type "D" — Mild conditions (No static load. Infrequent shock)

Use the chart below to determine the capacity index required for your application, based on static load and type of service. Refer to the tables at left to select the joint which best suits your needs. Order by part number from Lordco Supply.

When ordering Dynaflex Joints, other conditions of operation — presence of oil or other materials, temperature range, radial and torsional loads, magnitude, direction and frequency of other disturbances — should be mentioned.





Enlarged white section from above chart

• installation

Joint with Outer Sleeve: Clamp or press-fit outer sleeve into socket which has been machined to dimension shown in table at left. The force required to install the joint in the socket with a press-fit can be approximated from the formula:

Force (in pounds) = 2500 × Diameter × Length

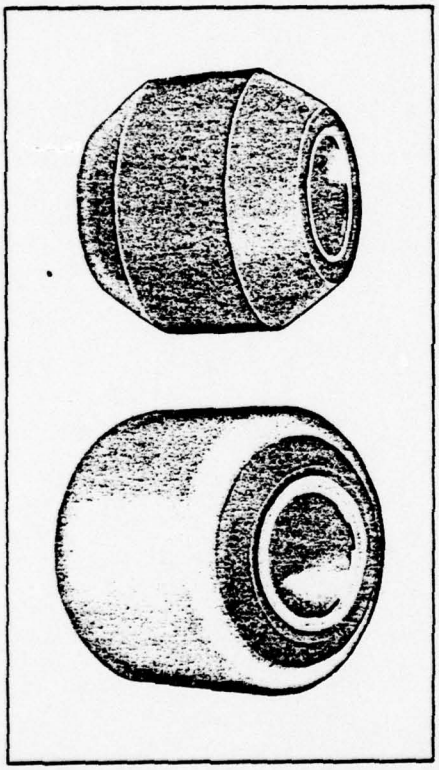
where D is outside diameter and L is length of the outer metal tube.

Attach inner member to mounting bracket by clamping bracket against ends of the tube. Another method of attaching requires that a shaft be press-fit through the inner metal tube.

Joint without Outer Sleeve: Since outer part of this type joint is the *flexing element, it must be compressed* and inserted directly into the socket. This is done with the aid of a funnel-shaped fixture and a suitable lubricant: P-80 Rubber lubricant (made by International Products Corp., P. O. Box 118, Trenton, New Jersey), linseed oil or castor oil.

Cast sockets are acceptable when dimensions conform to those shown in the table. Good casting practices must be followed, providing smooth finish and eliminating sharp corners. Inner member is attached by same methods described above.

Center Bonded Joints



Center Bonded Joints are used in pivot joints where the absorption of shock, attenuation of noise, reduction of wear and elimination of lubrication are requirements. They are designed to be loaded radially and utilize a soft torsional spring rate to provide freedom in rotation. High radial restraint maintains the alignment between joined parts. They are not intended for use where extreme rotational motion will occur.

Sizes are available with radial load capacities from 50 to 25,000 pounds, depending upon the type and severity of service. Two styles are offered: with and without an outer sleeve. The latter being more economical and permitting wider tolerances in the mating part.

Adaptable Center Bonded Joints feature specially compounded elastomer and high-strength bonded construction for maximum service life with minimal maintenance.

Typical applications include:

- heavy-duty highway equipment
- tamping equipment
- drilling equipment
- harvesters, combines
- industrial machinery

LORD Lord Kinematics

Selection

Factors which determine the selection of a center bonded joint are: (1) type and magnitude of load, (2) type of service and (3) *frequency and magnitude of* angular motion.

First determine the amount of static loading at the installation point. Then determine the conditions under which the joint will operate. The following should be used as a guide to type of service and part selection.

Type "A" — Extreme conditions (reversing dynamic load or distortion at high frequency—over 600 CPM). Use 1/3 the Type "B" radial load capacity rating.

Type "B" — Average conditions (constant radial load, intermittent shock). *Use the listed radial load capacity.*

	Part No.	Type "B" Radial Load Capacity	Spring Rate Radial Lb./in.	Spring Rate Torsional Lb.-in./Deg.	Recommended Socket Dimensions Diameter*	Recommended Socket Dimensions Length	A	B	C	D
Center Bonded Joints with Outer Member	J-5187-8	150	3,000	1.0	.997/.995	.62	.257	1.005/.998	1.00	.44
	J-5990-2	225	5,000	.9	.747/.745	1.00	.255/.250	.755/.748	1.25	.31
	J-5990-5	225	5,000	.9	.744/.742	1.00	.255/.250	.7565/.7450	1.25	.31
	J-5990-1	300	7,130	1.0	.747/.745	1.19	.255/.250	.755/.748	1.44	.31
	J-5187-2	325	4,350	2.6	.997/.995	1.12	.257	1.005/.998	1.50	.44
	J-3830-13	475	14,000	3.6	1.249/1.247	.88	.521/.511	1.255/1.250	1.00	.75
	J-5385-1	1,500	38,600	18.7	1.751/1.749	2.00	.4415/.4375	1.7535/1.7521	2.62	1.00
	J-5384-1	2,240	28,600	11.0	2.250/2.248	2.50	.4415/.4375	2.2529/2.2515	3.25	1.25
	J-5971-1	4,950	102,000	425	4.124/4.122	2.25	1.505/1.500	4.140/4.125	2.50	3.00
	J-6729-2	6,460	150,000	119	1.997/1.995	4.00	1.132/1.126	2.010/1.998	4.25	1.31
	J-6740-3	9,300	256,000	475	3.232/3.230	4.00	1.50	3.2335/3.2325	7.50	2.37
	J-6145-1	13,000	237,000	675	4.499/4.497	4.00	2.015/2.001	4.515/4.500	6.00	3.25
Center Bonded Joints Without Outer Member	J-6344-2	225	5,180	.9	.646	1.00	.255/.250	.73	1.25	.31
	J-6346-2	325	5,480	2.2	.905	1.25	.257	1.00	1.50	.44
	J-2005-2	400	18,500	3	.660	1.00	.312	.750	1.06	.44
	J-3830-6	475	13,700	4.8	1.065	.88	.521/.513	1.12	1.00	.75
	J-4705-2	1,000	25,200	16	1.285	1.44	.641	1.37	1.63	.88
	J-6424-1	1,200	39,200	23	1.375	1.47	.628/.625	1.45	1.53	1.00
	J-6310-1	1,450	27,500	25	1.720	1.56	1.006/1.001	1.84	1.69	1.25
	J-5385	1,500	26,200	24	1.585	2.12	.4415/.4375	1.75	2.62	1.00
	J-5950	2,000	40,000	94	2.220	1.88	1.319/1.313	2.39	2.24	1.50
	J-5384	2,700	36,400	46	2.000	2.75	.4415/.4375	2.18	3.25	1.25
	J-7121-2	2,950	105,000	100	1.750	2.75	1.006/1.000	1.935	2.99	1.19
	J-7231-1	3,000	168,000	81	2.440	1.81	1.453	2.625	1.94	2.00
	J-5506	3,200	24,600	58	2.750	2.25	1.361/1.359	2.97	2.75	2.00
	J-5807-1	4,175	96,000	105	2.310	3.00	1.252/1.249	2.47	3.37	1.62
	J-5971	4,950	145,000	520	3.700	2.25	1.505/1.500	3.93	2.50	3.00
	J-6729	6,400	164,000	123	1.750	4.00	1.132/1.126	1.86	4.25	1.31
	J-6145	13,000	312,000	796	4.000	4.00	2.015/2.000	4.185	6.00	3.25
	J-7069	24,500	285,000	2220	5.250	8.00	3.008/3.003	5.55	8.80	3.50

*Tolerance ±.015 for joints without outer member.

Installation:

Joint With Outer Sleeve: Clamp or press-fit the outer sleeve into a socket which has been machined to the dimensions shown in the table above. The force required to install the joint in the socket with a press-fit can be approximated from the formula:

Force (lbs.) = 2500 x diameter x length

The inner member is normally attached by clamping or bolting its extended ends to a mounting bracket. An alternate method would be to press-fit a shaft through the inner tube.

Joint Without Outer Sleeve: Since the outer part of this type joint is the flexing element, it must be compressed and inserted directly into a socket which has been machined to the dimensions shown in the table above. This is done with the aid of a funnel-shaped fixture and a suitable lubricant: P-80 Rubber Lubricant made by International Products Corporation, P. O. Box 118, Trenton, N. J.

The inner member attachment is accomplished in the same manner as described above for the joint with outer sleeve.

For further information contact: **Lord Kinematics, Lord Corporation, 1635 West 12th Street P. O. Box 2051, Erie, Pa. 16512. Telephone: 814/456-8511.**

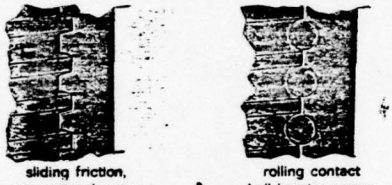
Printed in U.S.A. *© 1978, Lord Corporation* *76-2/78—5M*

LORD Lord Kinematics

WHY USE A BALL BEARING SCREW

90% EFFICIENCY

High mechanical efficiency of a Warner ball bearing screw results from the rolling contact of the ball bearings as compared to the relatively inefficient sliding friction of the conventional Acme screw.



sliding friction, conventional screw

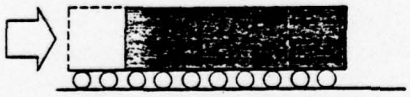
rolling contact ball bearing screw

NO STICK-SLIP

The substitution of rolling contact for sliding metal to metal contact minimizes starting friction and eliminates the tendency to stop-start and stutter when a slow smooth linear motion is desired. Very small, accurate increments of movement may be obtained through rolling contact.



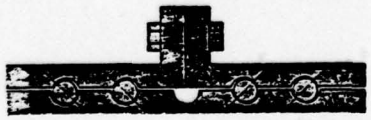
sliding friction—stutter, conventional screw



rolling contact—smooth motion, ball bearing screw

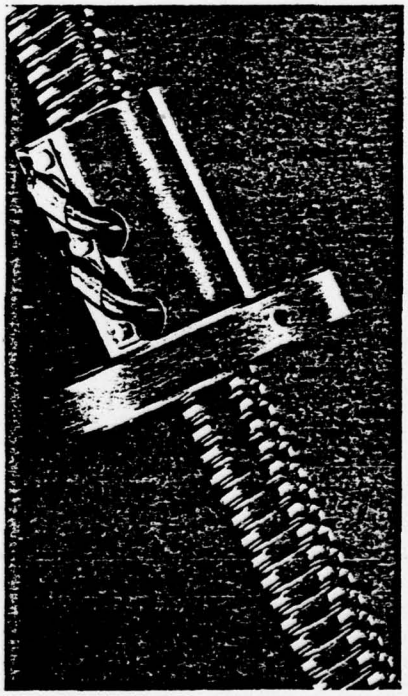
ZERO END PLAY ZERO BACKLASH

The high efficiency achieved through rolling contact permits the preloading of one ball nut against another to eliminate backlash or end play.



MINIMUM LUBRICATION

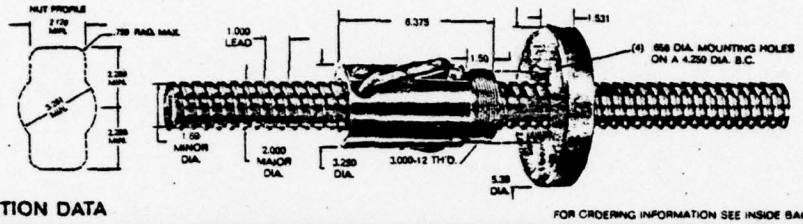
The need for heavy lubrication is eliminated when rolling contact is substituted for sliding contact. A minimum of oil or fine grease is required for optimum operation resulting in cleaner operation.



ACCURACY

A Warner Series R (rolled thread) ball bearing screw has a lead tolerance of ±.018 inch/foot. For special applications Beaver also offers Series G (ground precision thread) ball bearing screws with lead tolerances of ±.001 inch/foot, ±.0005 inch/foot, or ±.0002 inch/foot.

:R R-2001
AMETER
0 LEAD



SELECTION DATA

FOR ORDERING INFORMATION SEE INSIDE BACK COVER

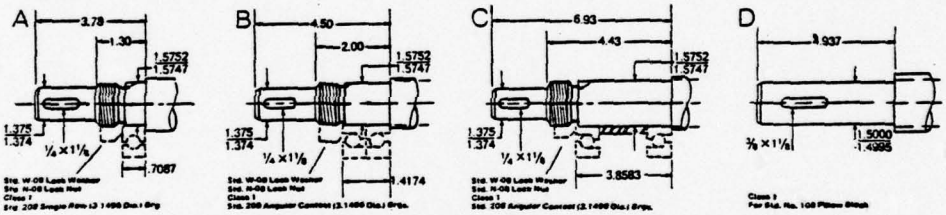
OPERATING LOAD

SPECIFICATIONS

THREADS: RIGHT HAND (CLASS 3)
STATIC RATING (NON BRINELLING): 104,000 POUNDS
LEAD TOLERANCE: ±.018 IN./FT.
NO. OF BALLS: 108 (.375 INCH DIAMETER)
MAXIMUM STANDARD LENGTH: 144"

HARDNESS: NUT—SURFACE R. 56 MIN. —CORE R. 40 MAX.
SCREW—SURFACE R. 56 MIN. —CORE R. 24-32
FINISH: BLACK OXIDE
MATERIAL: NUT—8620 SCREW—4150
BACKLASH (END PLAY): .028

STANDARD ENDS



BEARING SUPPORT VS. COLUMN STRENGTH & SAFE SPEED

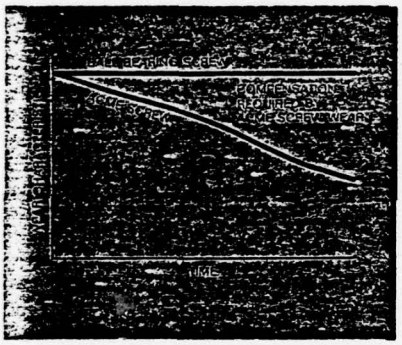
LENGTH X OR Y (INCHES)	MAX. SAFE COLUMN LOAD*—POUNDS				MAX. SAFE RATE OF TRAVEL*—INCHES/MIN.			
	FREE	SIMPLE	SIMPLE	RIGID	FREE	SIMPLE	SIMPLE	RIGID
	RIGID	SIMPLE	RIGID	RIGID	RIGID	SIMPLE	RIGID	RIGID
10	104,000	104,000	104,000	104,000	2,500	3,000	3,000	3,000
20	102,000	104,000	104,000	104,000	2,500	3,000	3,000	3,000
30	45,200	104,000	104,000	104,000	2,500	3,000	3,000	3,000
40	25,400	102,000	104,000	104,000	1,580	3,000	3,000	3,000
50		65,000	104,000	104,000	1,000	2,800	3,000	3,000
60		45,200	90,300	104,000	700	1,950	2,860	3,000
70		33,000	66,000	104,000	500	1,400	2,050	3,000
80			50,800	102,000	390	1,100	1,610	2,450
90			39,500	79,000	300	860	1,280	1,910
100			32,500	65,000	250	700	1,020	1,560
110				53,000	200	580	850	1,290
120				45,100	180	490	720	1,090
130	REQUIRES SPECIAL CONSIDERATION			38,500	150	430	630	950
140				33,000	130	370	540	820

*INCLUDES A 20% MARGIN OF SAFETY

24

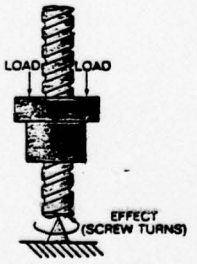
NO ADJUSTING FOR WEAR

The useful life of a Warner ball bearing screw is determined by metal fatigue rather than the ordinary wear characteristic of a conventional screw. Due to the rolling contact, very little dimensional change occurs over the life of a ball bearing screw, thus eliminating the need for frequent compensating adjustments.

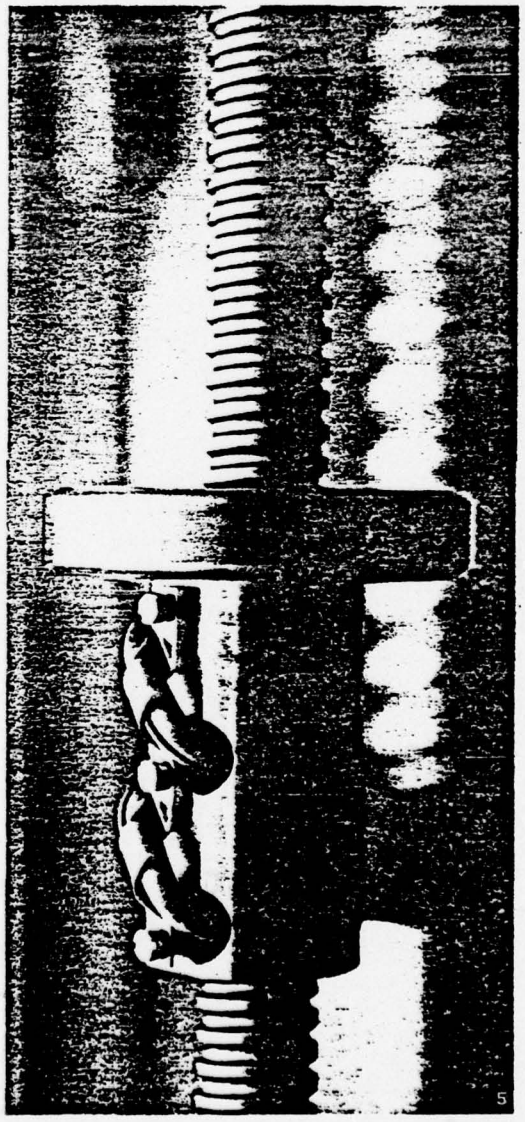


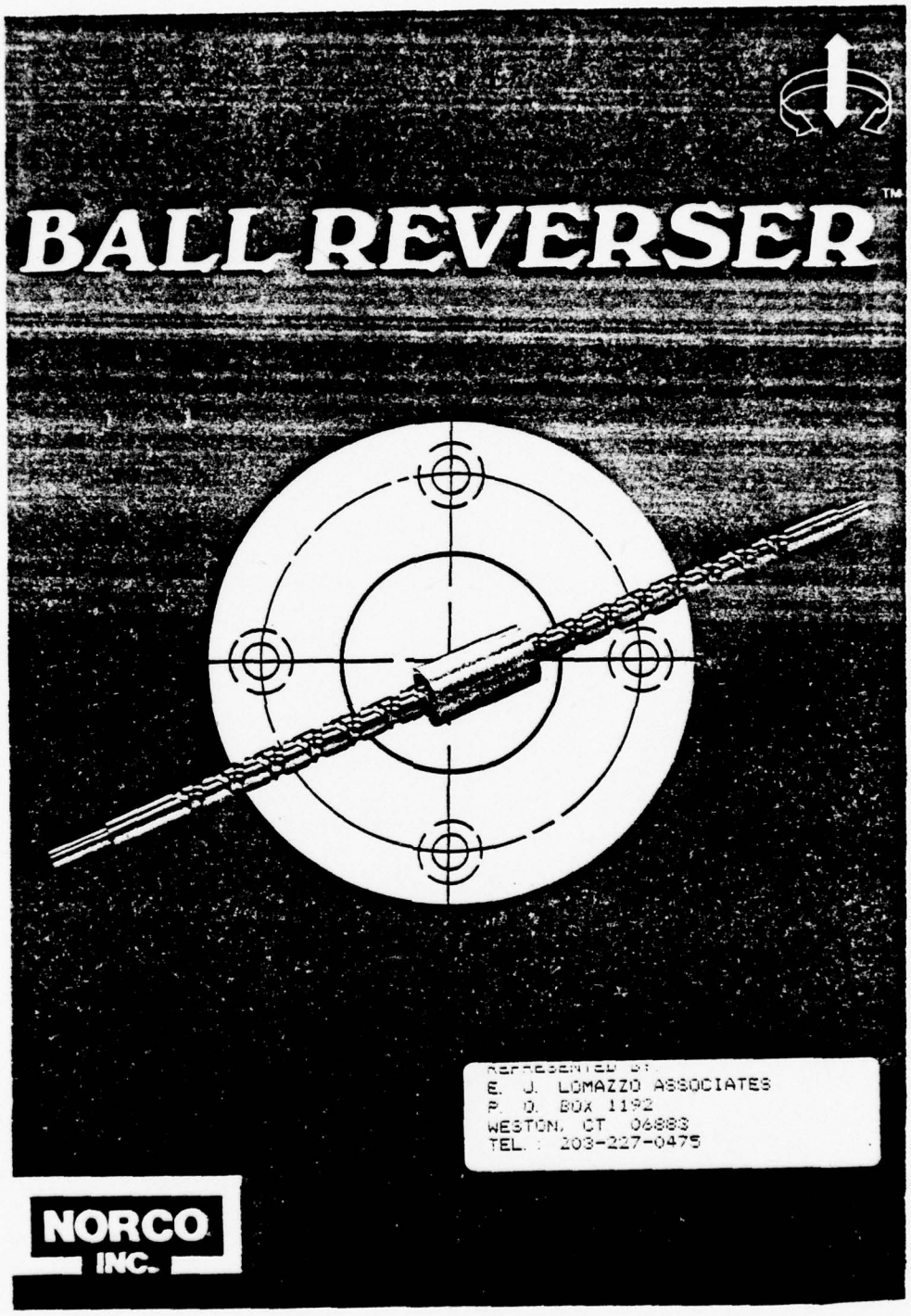
REVERSIBILITY

Because of its inherent efficiency (90% +), a Warner ball bearing screw can be used to convert a linear force to a rotary torque.

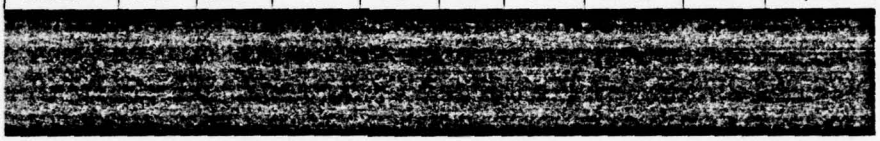


linear force on nut causes screw to turn



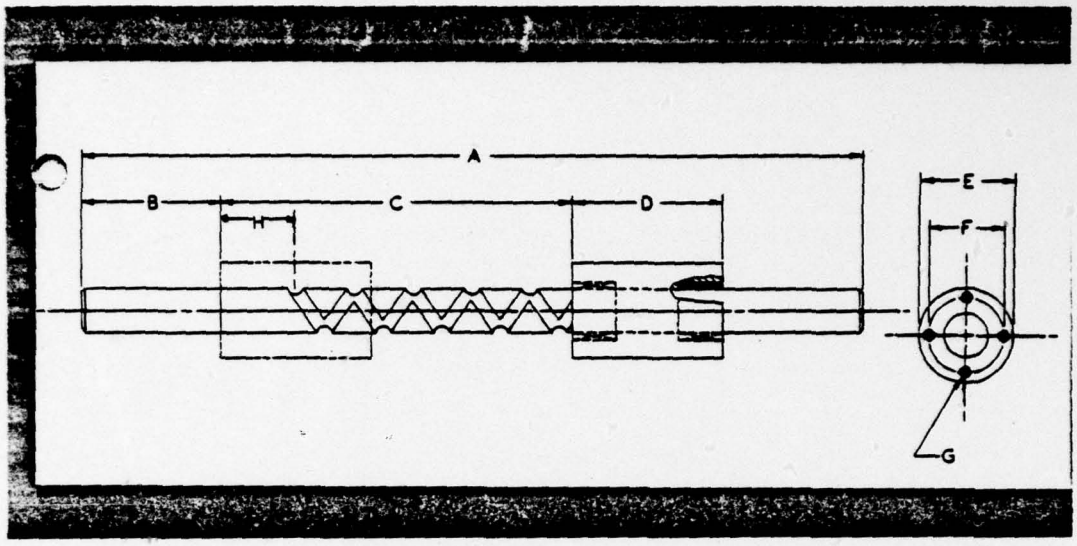

BALL REVERSER™
REPRESENTED BY:
E. J. LOMAZZO ASSOCIATES
P. O. BOX 1192
WESTON, CT 06883
TEL.: 203-227-0475
NORCO
INC.

Part No.	Shaft O.D.	Lead	Approximate Available End Material (B)	Nut Length (D)	Nut O.D. (E)	Bolt Circle (F)	Tap (G)	Nut Overtravel (H)	Screw Material
BRC1600	.375	.500	1.5	1.38	.98	.781	#6-32 UNC-2B	.74	17-4 pH
BRC1700	.500	.750	2.0	1.87	1.22	.937	#6-32 UNC-2B	1.00	17-4 pH
BR1800	.750	1.000	3.9	2.56	1.62	1.312	#8-32 UNC-2B	1.34	Alloy Steel
BR1900	1.250	1.250	6.1	4.13	2.37	1.937	1/4-20 UNC-2B	2.27	Alloy Steel
BR2000	1.750	2.000	7.8	5.00	3.25	2.687	5/16-18 UNC-2B	2.64	Alloy Steel
BR2100	2.500	3.000	7.8	6.87	4.47	3.750	7/16-20 UNF-2B	3.64	Alloy Steel



PART #	DIMENSION "C"	DIMENSION "A"
BRC1602-1	.440	4.820
BRC1603-1	.690	5.070
BRC1604-1	.940	5.320
BRC1605-1	1.190	5.570
BRC1606-1	1.440	5.820
BRC1607-1	1.690	6.070
BRC1608-1	1.940	6.320
BRC1609-1	2.190	6.570
BRC1610-1	2.440	6.820
BRC1611-1	2.690	7.070
BRC1612-1	2.940	7.320
BRC1613-1	3.190	7.570
BRC1614-1	3.440	7.820
BRC1615-1	3.690	8.070
BRC1616-1	3.940	8.320
BRC1617-1	4.190	8.570
BRC1618-1	4.440	8.820
BRC1619-1	4.690	9.070
BRC1620-1	4.940	9.320
BRC1621-1	5.190	9.570
BRC1622-1	5.440	9.820
BRC1623-1	5.690	10.070
BRC1624-1	5.940	10.320
BRC1625-1	6.190	10.570
BRC1626-1	6.440	10.820
BRC1627-1	6.690	11.070
BRC1628-1	6.940	11.320
BRC1629-1	7.190	11.570
BRC1630-1	7.440	11.820
BRC1631-1	7.690	12.070
BRC1632-1	7.940	12.320
BRC1633-1	8.190	12.570
BRC1634-1	8.440	12.820
BRC1635-1	8.690	13.070
BRC1636-1	8.940	13.320
BRC1637-1	9.190	13.570
BRC1638-1	9.440	13.820
BRC1639-1	9.690	14.070
BRC1640-1	9.940	14.320
BRC1641-1	10.190	14.570
BRC1642-1	10.440	14.820
BRC1643-1	10.690	15.070
BRC1644-1	10.940	15.320
BRC1645-1	11.190	15.570
BRC1646-1	11.440	15.820
BRC1647-1	11.690	16.070
BRC1648-1	11.940	16.320
BRC1649-1	12.190	16.570
BRC1650-1	12.440	16.820

PART #	DIMENSION "C"	DIMENSION "A"
BRC1651-1	12.690	17.070
BRC1652-1	12.940	17.320
BRC1653-1	13.190	17.570
BRC1654-1	13.440	17.820
BRC1655-1	13.690	18.070
BRC1656-1	13.940	18.320
BRC1657-1	14.190	18.570
BRC1658-1	14.440	18.820
BRC1659-1	14.690	19.070
BRC1660-1	14.940	19.320
BRC1661-1	15.190	19.570
BRC1662-1	15.440	19.820
BRC1663-1	15.690	20.070
BRC1664-1	15.940	20.320
BRC1665-1	16.190	20.570
BRC1666-1	16.440	20.820
BRC1667-1	16.690	21.070
BRC1668-1	16.940	21.320
BRC1669-1	17.190	21.570
BRC1670-1	17.440	21.820
BRC1671-1	17.690	22.070
BRC1672-1	17.940	22.320
BRC1673-1	18.190	22.570
BRC1674-1	18.440	22.820
BRC1675-1	18.690	23.070
BRC1676-1	18.940	23.320
BRC1677-1	19.190	23.570
BRC1678-1	19.440	23.820
BRC1679-1	19.690	24.070
BRC1680-1	19.940	24.320
BRC1681-1	20.190	24.570
BRC1682-1	20.440	24.820
BRC1683-1	20.690	25.070
BRC1684-1	20.940	25.320
BRC1685-1	21.190	25.570
BRC1686-1	21.440	25.820
BRC1687-1	21.690	26.070
BRC1688-1	21.940	26.320
BRC1689-1	22.190	26.570
BRC1690-1	22.440	26.820
BRC1691-1	22.690	27.070
BRC1692-1	22.940	27.320
BRC1693-1	23.190	27.570
BRC1694-1	23.440	27.820
BRC1695-1	23.690	28.070
BRC1696-1	23.940	28.320
BRC1697-1	24.190	28.570
BRC1698-1	24.440	28.820



PART #	DIMENSION "C"	DIMENSION "A"
BRC1702-1	.653	6.523
BRC1703-1	1.028	6.898
BRC1704-1	1.403	7.273
BRC1705-1	1.778	7.648
BRC1706-1	2.153	8.023
BRC1707-1	2.528	8.398
BRC1708-1	2.903	8.773
BRC1709-1	3.278	9.148
BRC1710-1	3.653	9.523
BRC1711-1	4.028	9.898
BRC1712-1	4.403	10.273
BRC1713-1	4.778	10.648
BRC1714-1	5.153	11.023
BRC1715-1	5.528	11.398
BRC1716-1	5.903	11.773
BRC1717-1	6.278	12.148
BRC1718-1	6.653	12.523
BRC1719-1	7.028	12.898
BRC1720-1	7.403	13.273
BRC1721-1	7.778	13.648
BRC1722-1	8.153	14.023
BRC1723-1	8.528	14.398
BRC1724-1	8.903	14.773
BRC1725-1	9.278	15.148
BRC1726-1	9.653	15.523
BRC1727-1	10.028	15.898
BRC1728-1	10.403	16.273
BRC1729-1	10.778	16.648
BRC1730-1	11.153	17.023
BRC1731-1	11.528	17.398
BRC1732-1	11.903	17.773
BRC1733-1	12.278	18.148
BRC1734-1	12.653	18.523
BRC1735-1	13.028	18.898
BRC1736-1	13.403	19.273
BRC1737-1	13.778	19.648
BRC1738-1	14.153	20.023
BRC1739-1	14.528	20.398
BRC1740-1	14.903	20.773
BRC1741-1	15.278	21.148
BRC1742-1	15.653	21.523
BRC1743-1	16.028	21.898
BRC1744-1	16.403	22.273
BRC1745-1	16.778	22.648
BRC1746-1	17.153	23.023
BRC1747-1	17.528	23.398
BRC1748-1	17.903	23.773
BRC1749-1	18.278	24.148
BRC1750-1	18.653	24.523

PART #	DIMENSION "C"	DIMENSION "A"
BRC1751-1	19.028	24.898
BRC1752-1	19.403	25.273
BRC1753-1	19.778	25.648
BRC1754-1	20.153	26.023
BRC1755-1	20.528	26.398
BRC1756-1	20.903	26.773
BRC1757-1	21.278	27.148
BRC1758-1	21.653	27.523
BRC1759-1	22.028	27.898
BRC1760-1	22.403	28.273
BRC1761-1	22.778	28.648
BRC1762-1	23.153	29.023
BRC1763-1	23.528	29.398
BRC1764-1	23.903	29.773
BRC1765-1	24.278	30.148
BRC1766-1	24.653	30.523
BRC1767-1	25.028	30.898
BRC1768-1	25.403	31.273
BRC1769-1	25.778	31.648
BRC1770-1	26.153	32.023
BRC1771-1	26.528	32.398
BRC1772-1	26.903	32.773
BRC1773-1	27.278	33.148
BRC1774-1	27.653	33.523
BRC1775-1	28.028	33.898
BRC1776-1	28.403	34.273
BRC1777-1	28.778	34.648
BRC1778-1	29.153	35.023
BRC1779-1	29.528	35.398
BRC1780-1	29.903	35.773
BRC1781-1	30.278	36.148
BRC1782-1	30.653	36.523
BRC1783-1	31.028	36.898
BRC1784-1	31.403	37.273
BRC1785-1	31.778	37.648
BRC1786-1	32.153	38.023
BRC1787-1	32.528	38.398
BRC1788-1	32.903	38.773
BRC1789-1	33.278	39.148
BRC1790-1	33.653	39.523
BRC1791-1	34.028	39.898
BRC1792-1	34.403	40.273
BRC1793-1	34.778	40.648
BRC1794-1	35.153	41.023
BRC1795-1	35.528	41.398
BRC1796-1	35.903	41.773
BRC1797-1	36.278	42.148
BRC1798-1	36.653	42.523
BRC1799-1	37.028	42.898

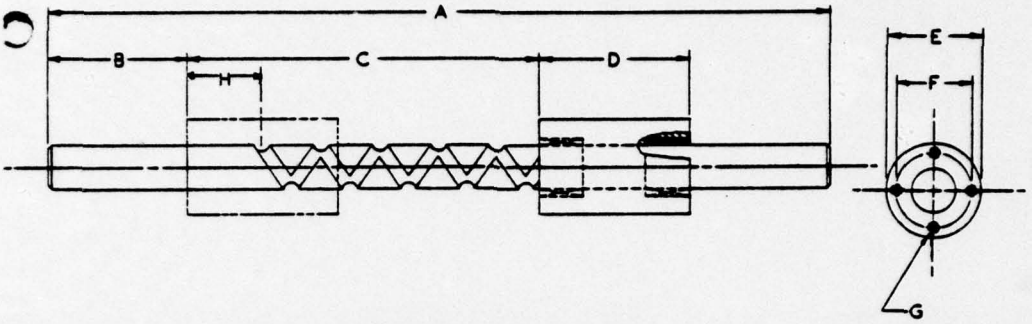
Lot numbers as well as part numbers must be shown on reorders.

Part No.	Shaft O.D.	Lead	Approximate Available End Material (B)	Nut Length (D)	Nut O.D. (E)	Bolt Circle (F)	Tap (G)	Nut Overtravel (H)	Screw Material
BRC1600	.375	.500	1.5	1.38	.98	.781	#6-32 UNC-2B	.74	17-4 pH
BRC1700	.500	.750	2.0	1.87	1.22	.937	#6-32 UNC-2B	1.00	17-4 pH
BR1800	.750	1.000	3.9	2.56	1.62	1.312	#8-32 UNC-2B	1.34	Alloy Steel
BR1900	1.250	1.250	6.1	4.13	2.37	1.937	1/4-20 UNC-2B	2.27	Alloy Steel
BR2000	1.750	2.000	7.8	5.00	3.25	2.687	5/16-18 UNC-2B	2.64	Alloy Steel
BR2100	2.500	3.000	7.8	6.87	4.47	3.750	7/16-20 UNF-2B	3.64	Alloy Steel

PART #	DIMENSION "C"	DIMENSION "A"
BR1802-1	.878	11.438
BR1803-1	1.378	11.938
BR1804-1	1.878	12.438
BR1805-1	2.378	12.938
BR1806-1	*2.878*	*13.439*
BR1807-1	3.378	13.938
BR1808-1	3.878	14.438
BR1809-1	4.378	14.938
BR1810-1	4.878	15.438
BR1811-1	5.378	15.938
BR1812-1	5.878	16.438
BR1813-1	6.378	16.938
BR1814-1	6.878	17.438
BR1815-1	7.378	17.938
BR1816-1	7.878	18.438
BR1817-1	8.378	18.938
BR1818-1	8.878	19.438
BR1819-1	9.378	19.938
BR1820-1	9.878	20.438
BR1821-1	10.378	20.938
BR1822-1	10.878	21.438
BR1823-1	11.378	21.938
BR1824-1	11.878	22.438
BR1825-1	12.378	22.938
BR1826-1	12.878	23.438
BR1827-1	13.378	23.938
BR1828-1	13.878	24.438
BR1829-1	14.378	24.938
BR1830-1	14.878	25.438
BR1831-1	15.378	25.938
BR1832-1	15.878	26.438
BR1833-1	16.378	26.938
BR1834-1	16.878	27.438
BR1835-1	17.378	27.938
BR1836-1	17.878	28.438
BR1837-1	18.378	28.938
BR1838-1	18.878	29.438
BR1839-1	19.378	29.938
BR1840-1	19.878	30.438
BR1841-1	20.378	30.938
BR1842-1	20.878	31.438
BR1843-1	21.378	31.938
BR1844-1	21.878	32.438
BR1845-1	22.378	32.938
BR1846-1	22.878	33.438
BR1847-1	23.378	33.938
BR1848-1	23.878	34.438
BR1849-1	24.378	34.938
BR1850-1	24.878	35.438

PART #	DIMENSION "C"	DIMENSION "A"
BR1851-1	25.378	35.938
BR1852-1	25.878	36.438
BR1853-1	26.378	36.938
BR1854-1	26.878	37.438
BR1855-1	*27.378*	*37.938*
BR1856-1	27.878	38.438
BR1857-1	28.378	38.938
BR1858-1	28.878	39.438
BR1859-1	29.378	39.938
BR1860-1	29.878	40.438
BR1861-1	30.378	40.938
BR1862-1	30.878	41.438
BR1863-1	31.378	41.938
BR1864-1	31.878	42.438
BR1865-1	32.378	42.938
BR1866-1	32.878	43.438
BR1867-1	33.378	43.938
BR1868-1	33.878	44.438
BR1869-1	34.378	44.938
BR1870-1	34.878	45.438
BR1871-1	35.378	45.938
BR1872-1	35.878	46.438
BR1873-1	36.378	46.938
BR1874-1	36.878	47.438
BR1875-1	37.378	47.938
BR1876-1	37.878	48.438
BR1877-1	38.378	48.938
BR1878-1	38.878	49.438
BR1879-1	39.378	49.938
BR1880-1	39.878	50.438
BR1881-1	40.378	50.938
BR1882-1	40.878	51.438
BR1883-1	41.378	51.938
BR1884-1	41.878	52.438
BR1885-1	42.378	52.938
BR1886-1	42.878	53.438
BR1887-1	43.378	53.938
BR1888-1	43.878	54.438
BR1889-1	44.378	54.938
BR1890-1	44.878	55.438
BR1891-1	45.378	55.938
BR1892-1	45.878	56.438
BR1893-1	46.378	56.938
BR1894-1	46.878	57.438
BR1895-1	47.378	57.938
BR1896-1	47.878	58.438
BR1897-1	48.378	58.938
BR1898-1	48.878	59.438
BR1899-1	49.378	59.938

Lot numbers as well as part numbers must be shown on reorders.

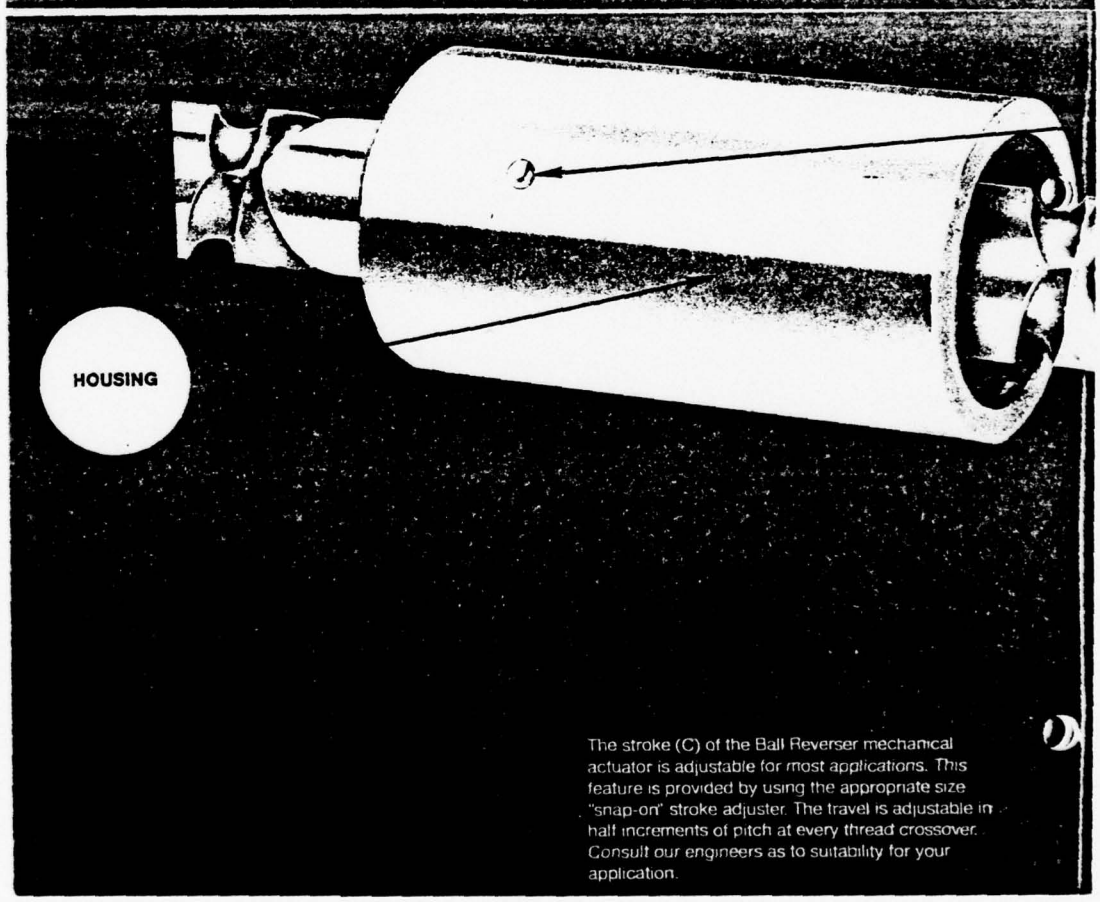


PART #	DIMENSION "C"	DIMENSION "A"
BR1902-1	1.122	17.252
BR1903-1	1.747	17.877
BR1904-1	2.372	18.502
BR1905-1	2.997	19.127
BR1906-1	3.622	19.752
BR1907-1	4.247	20.377
BR1908-1	4.872	21.002
BR1909-1	5.497	21.627
BR1910-1	6.122	22.252
BR1911-1	6.747	22.877
BR1912-1	*7.372*	*23.502*
BR1913-1	7.997	24.127
BR1914-1	8.622	24.752
BR1915-1	9.247	25.377
BR1916-1	9.872	26.002
BR1917-1	10.497	26.627
BR1918-1	11.122	27.252
BR1919-1	11.747	27.877
BR1920-1	12.372	28.502
BR1921-1	12.997	29.127
BR1922-1	13.622	29.752
BR1923-1	14.247	30.377
BR1924-1	14.872	31.002
BR1925-1	15.497	31.627
BR1926-1	16.122	32.252
BR1927-1	16.747	32.877
BR1928-1	17.372	33.502
BR1829-1	17.997	34.127
BR1930-1	18.622	34.752
BR1931-1	19.247	35.377
BR1932-1	19.872	36.002
BR1933-1	20.497	36.627
BR1934-1	21.122	37.252
BR1935-1	21.747	37.877
BR1936-1	22.372	38.502
BR1937-1	22.997	39.127
BR1938-1	23.622	39.752
BR1939-1	24.247	40.377
BR1940-1	24.872	41.002
BR1941-1	25.497	41.627
BR1942-1	26.122	42.252
BR1943-1	26.747	42.877
BR1944-1	27.372	43.502
BR1945-1	27.997	44.127
BR1946-1	28.622	44.752
BR1947-1	29.247	45.377
BR1948-1	29.872	46.002
BR1949-1	30.497	46.627
BR1950-1	31.122	47.252

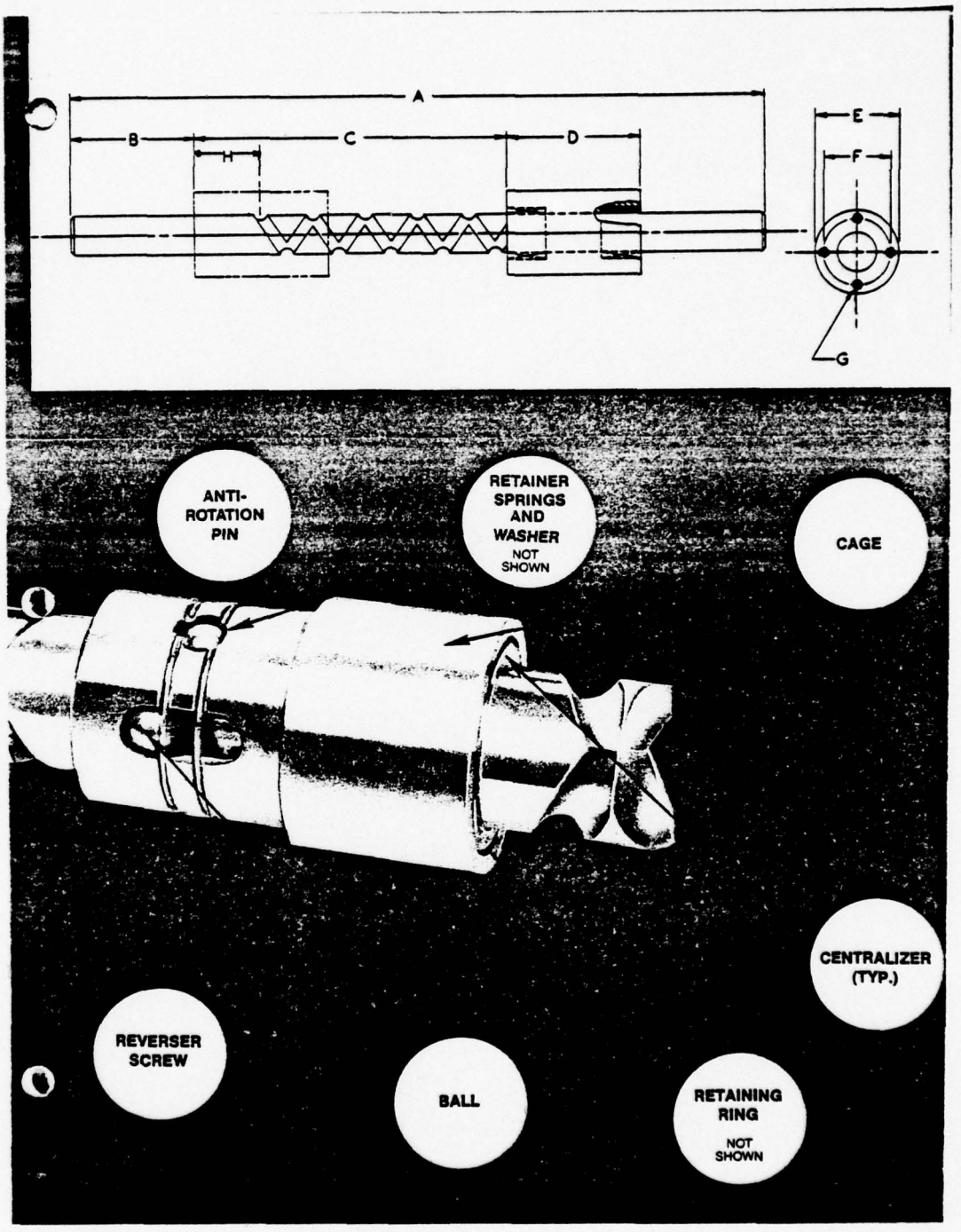
PART #	DIMENSION "C"	DIMENSION "A"
BR1951-1	31.747	47.877
BR1952-1	32.372	48.502
BR1953-1	32.997	49.127
BR1954-1	33.622	49.752
BR1955-1	34.247	50.377
BR1956-1	34.872	51.002
BR1957-1	35.497	51.627
BR1958-1	36.122	52.252
BR1959-1	36.747	52.877
BR1960-1	37.372	53.502
BR1961-1	37.997	54.127
BR1962-1	38.622	54.752
BR1963-1	39.247	55.377
BR1964-1	39.872	56.002
BR1965-1	40.497	56.627
BR1966-1	41.122	57.252
BR1967-1	41.747	57.877
BR1968-1	42.372	58.502
BR1969-1	42.997	59.127
BR1970-1	43.622	59.752
BR1971-1	44.247	60.377
BR1972-1	44.872	61.002
BR1973-1	45.497	61.627
BR1974-1	46.122	62.252
BR1975-1	46.747	62.877
BR1976-1	47.372	63.502
BR1977-1	47.997	64.127
BR1978-1	48.622	64.752
BR1979-1	49.247	65.377
BR1980-1	49.872	66.002
BR1981-1	50.497	66.627
BR1982-1	51.122	67.252
BR1983-1	51.747	67.877
BR1984-1	52.372	68.502
BR1985-1	52.997	69.127
BR1986-1	53.622	69.752
BR1987-1	54.247	70.377
BR1988-1	54.872	71.002
BR1989-1	55.497	71.627
BR1990-1	56.122	72.252
BR1991-1	56.747	72.877
BR1992-1	57.372	73.502
BR1993-1	57.997	74.127
BR1994-1	58.622	74.752
BR1995-1	59.247	75.377
BR1996-1	59.872	76.002
BR1997-1	60.497	76.627
BR1998-1	61.122	77.252
BR1999-1	61.747	77.877

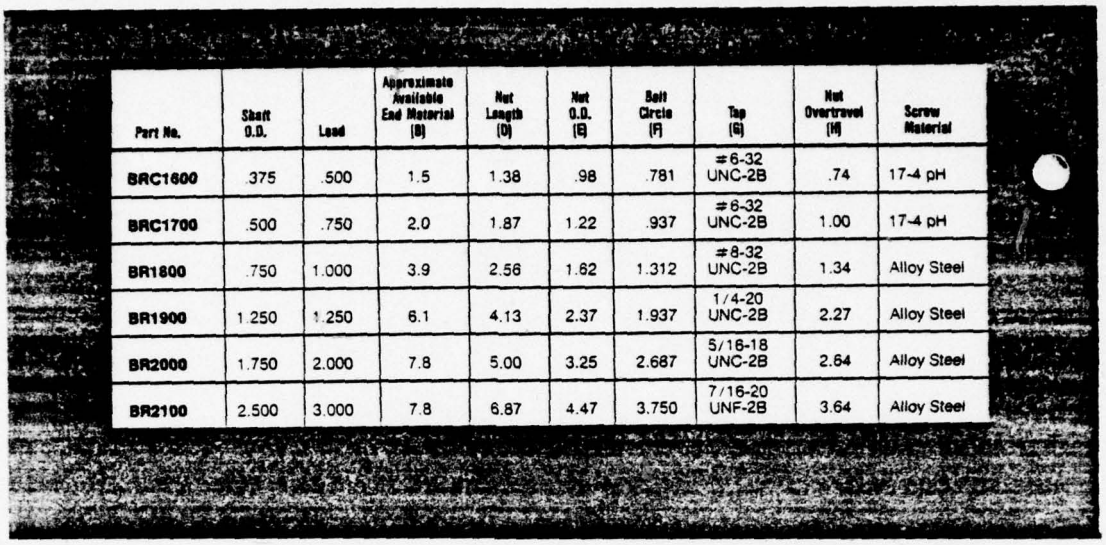
Lot numbers as well as part numbers must be shown on reorders.

Part No.	Shaft O.D.	Lead	Approximate Available End Material (B)	Nut Length (D)	Nut O.D. (E)	Bolt Circle (F)	Tap (G)	Nut Overtravel (H)	Screw Material
BRC1600	.375	.500	1.5	1.38	.98	.781	#6-32 UNC-2B	.74	17-4 pH
BRC1700	.500	.750	2.0	1.87	1.22	.937	#6-32 UNC-2B	1.00	17-4 pH
BR1800	.750	1.000	3.9	2.56	1.62	1.312	#8-32 UNC-2B	1.34	Alloy Steel
BR1900	1.250	1.250	6.1	4.13	2.37	1.937	1/4-20 UNC-2B	2.27	Alloy Steel
BR2000	1.750	2.000	7.8	5.00	3.25	2.687	5/16-18 UNC-2B	2.64	Alloy Steel
BR2100	2.500	3.000	7.8	6.87	4.47	3.750	7/16-20 UNF-2B	3.64	Alloy Steel



The stroke (C) of the Ball Reverser mechanical actuator is adjustable for most applications. This feature is provided by using the appropriate size "snap-on" stroke adjuster. The travel is adjustable in half increments of pitch at every thread crossover. Consult our engineers as to suitability for your application.


A
B
C
D
E
F
G
H
ANTI-ROTATION PIN
RETAINER SPRINGS AND WASHER NOT SHOWN
CAGE
CENTRALIZER (TYP.)
REVERSER SCREW
BALL
RETAINING RING NOT SHOWN

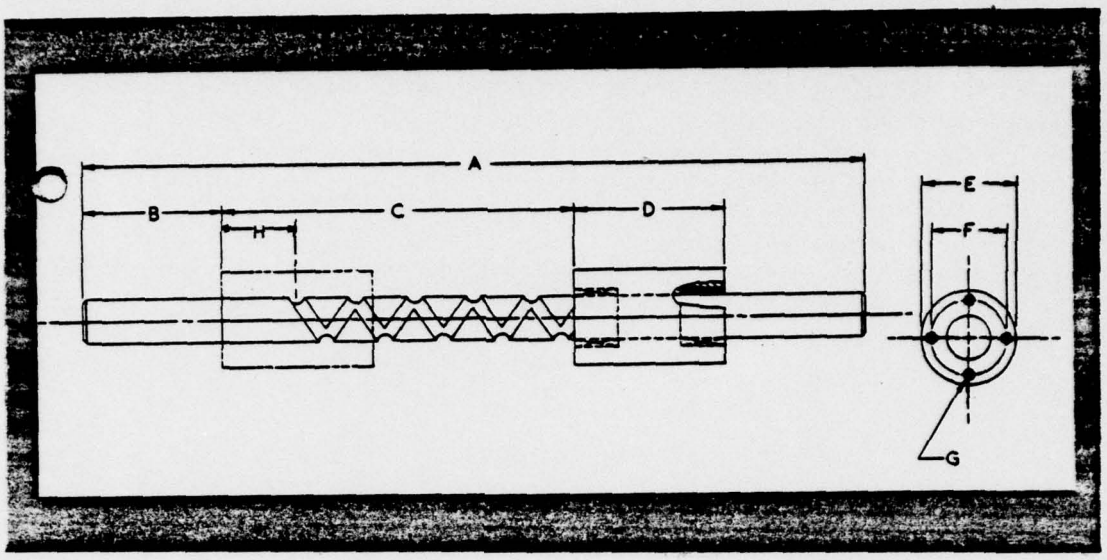


Part No.	Shaft O.D.	Lead	Approximate Available End Material (B)	Nut Length (D)	Nut O.D. (E)	Bolt Circle (F)	Tap (G)	Nut Overtravel (H)	Screw Material
SRC1600	.375	.500	1.5	1.38	.98	.781	#6-32 UNC-2B	.74	17-4 pH
SRC1700	.500	.750	2.0	1.87	1.22	.937	#6-32 UNC-2B	1.00	17-4 pH
BR1800	.750	1.000	3.9	2.56	1.62	1.312	#8-32 UNC-2B	1.34	Alloy Steel
BR1900	1.250	1.250	6.1	4.13	2.37	1.937	1/4-20 UNC-2B	2.27	Alloy Steel
BR2000	1.750	2.000	7.8	5.00	3.25	2.687	5/16-18 UNC-2B	2.64	Alloy Steel
BR2100	2.500	3.000	7.8	6.87	4.47	3.750	7/16-20 UNF-2B	3.64	Alloy Steel

PART #	DIMENSION "C"	DIMENSION "A"
BR2002-1	1.750	22.750
BR2003-1	2.750	23.750
BR2004-1	3.750	24.750
BR2005-1	4.750	25.750
BR2006-1	5.750	26.750
BR2007-1	6.750	27.750
BR2008-1	7.750	28.750
BR2009-1	8.750	29.750
BR2010-1	9.750	30.750
BR2011-1	10.750	31.750
BR2012-1	11.750	32.750
BR2013-1	12.750	33.750
BR2014-1	13.750	34.750
BR2015-1	14.750	35.750
BR2016-1	15.750	36.750
BR2017-1	16.750	37.750
BR2018-1	17.750	38.750
BR2019-1	18.750	39.750
BR2020-1	19.750	40.750
BR2021-1	20.750	41.750
BR2022-1	21.750	42.750
BR2023-1	22.750	43.750
BR2024-1	23.750	44.750
BR2025-1	24.750	45.750
BR2026-1	25.750	46.750
BR2027-1	26.750	47.750
BR2028-1	27.750	48.750
BR2029-1	28.750	49.750
BR2030-1	29.750	50.750
BR2031-1	30.750	51.750
BR2032-1	31.750	52.750
BR2033-1	32.750	53.750
BR2034-1	33.750	54.750
BR2035-1	34.750	55.750
BR2036-1	35.750	56.750
BR2037-1	36.750	57.750
BR2038-1	37.750	58.750
BR2039-1	38.750	59.750
BR2040-1	39.750	60.750
BR2041-1	40.750	61.750
BR2042-1	41.750	62.750
BR2043-1	42.750	63.750
BR2044-1	43.750	64.750
BR2045-1	44.750	65.750
BR2046-1	45.750	66.750
BR2047-1	46.750	67.750
BR2048-1	47.750	68.750
BR2049-1	48.750	69.750
BR2050-1	49.750	70.750

PART #	DIMENSION "C"	DIMENSION "A"
BR2051-1	50.750	71.750
BR2052-1	51.750	72.750
BR2053-1	52.750	73.750
BR2054-1	53.750	74.750
BR2055-1	54.750	75.750
BR2056-1	55.750	76.750
BR2057-1	56.750	77.750
BR2058-1	57.750	78.750
BR2059-1	58.750	79.750
BR2060-1	59.750	80.750
BR2061-1	60.750	81.750
BR2062-1	61.750	82.750
BR2063-1	62.750	83.750
BR2064-1	63.750	84.750
BR2065-1	64.750	85.750
BR2066-1	65.750	86.750
BR2067-1	66.750	87.750
BR2068-1	67.750	88.750
BR2069-1	68.750	89.750
BR2070-1	69.750	90.750
BR2071-1	70.750	91.750
BR2072-1	71.750	92.750
BR2073-1	72.750	93.750
BR2074-1	73.750	94.750
BR2075-1	74.750	95.750
BR2076-1	75.750	96.750
BR2077-1	76.750	97.750
BR2078-1	77.750	98.750
BR2079-1	78.750	99.750
BR2080-1	79.750	100.750
BR2081-1	80.750	101.750
BR2082-1	81.750	102.750
BR2083-1	82.750	103.750
BR2084-1	83.750	104.750
BR2085-1	84.750	105.750
BR2086-1	85.750	106.750
BR2087-1	86.750	107.750
BR2088-1	87.750	108.750
BR2089-1	88.750	109.750
BR2090-1	89.750	110.750
BR2091-1	90.750	111.750
BR2092-1	91.750	112.750
BR2093-1	92.750	113.750
BR2094-1	93.750	114.750
BR2095-1	94.750	115.750
BR2096-1	95.750	116.750
BR2097-1	96.750	117.750
BR2098-1	97.750	118.750
BR2099-1	98.750	119.750

Lot numbers as well as part numbers must be shown on reorders.



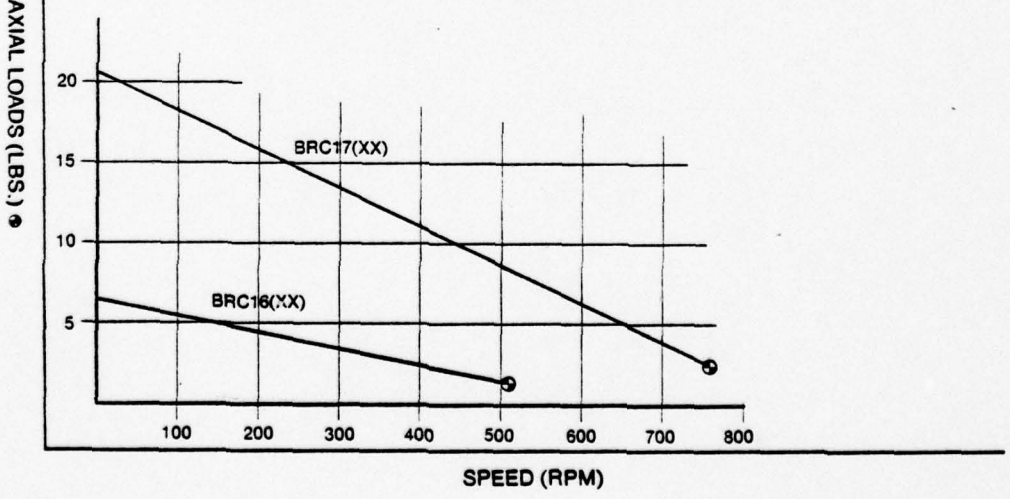
PART #	DIMENSION "C"	DIMENSION "A"
BR2102-1	2.500	25.370
BR2103-1	4.000	26.870
BR2104-1	5.500	28.370
BR2105-1	7.000	29.870
BR2106-1	8.500	31.370
BR2107-1	10.000	32.870
BR2108-1	11.500	34.370
BR2109-1	13.000	35.870
BR2110-1	14.500	37.370
BR2111-1	16.000	38.870
BR2112-1	17.500	40.370
BR2113-1	19.000	41.870
BR2114-1	20.500	43.370
BR2115-1	22.000	44.870
BR2116-1	23.500	46.370
BR2117-1	25.000	47.870
BR2118-1	26.500	49.370
BR2119-1	28.000	50.870
BR2120-1	29.500	52.370
BR2121-1	31.000	53.870
BR2122-1	32.500	55.370
BR2123-1	34.000	56.870
BR2124-1	35.500	58.370
BR2125-1	37.000	59.870
BR2126-1	38.500	61.370
BR2127-1	40.000	62.870
BR2128-1	41.500	64.370
BR2129-1	43.000	65.870
BR2130-1	44.500	67.370
BR2131-1	46.000	68.870
BR2132-1	47.500	70.370
BR2133-1	49.000	71.870
BR2134-1	50.500	73.370
BR2135-1	52.000	74.870
BR2136-1	53.500	76.370
BR2137-1	55.000	77.870
BR2138-1	56.500	79.370
BR2139-1	58.000	80.870
BR2140-1	59.500	82.370
BR2141-1	61.000	83.870
BR2142-1	62.500	85.370
BR2143-1	64.000	86.870
BR2144-1	65.500	88.370
BR2145-1	67.000	89.870
BR2146-1	68.500	91.370
BR2147-1	70.000	92.870
BR2148-1	71.500	94.370
BR2149-1	73.000	95.870
BR2150-1	74.500	97.370

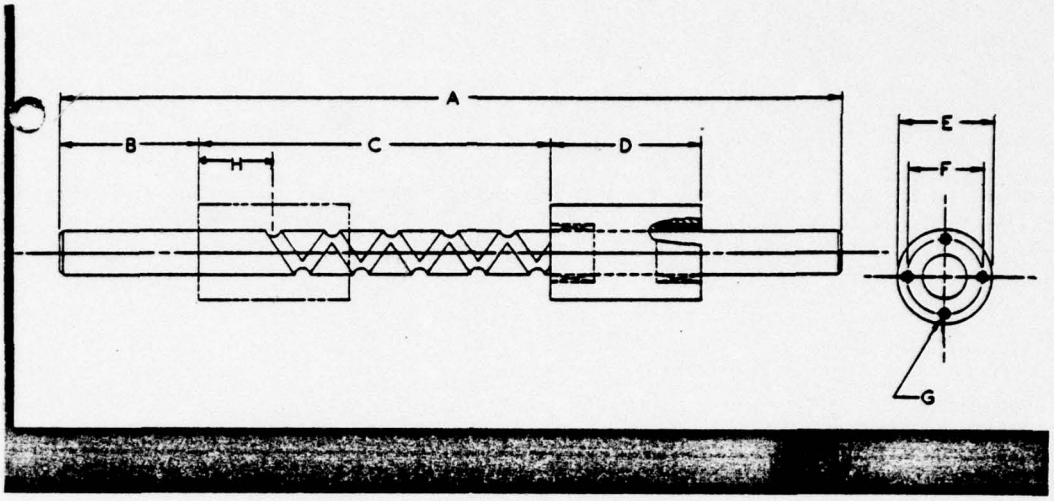
PART #	DIMENSION "C"	DIMENSION "A"
BR2151-1	76.000	98.870
BR2152-1	77.500	100.370
BR2153-1	79.000	101.870
BR2154-1	80.500	103.370
BR2155-1	82.000	104.870
BR2156-1	83.500	106.370
BR2157-1	85.000	107.870
BR2158-1	86.500	109.370
BR2159-1	88.000	110.870
BR2160-1	89.500	112.370
BR2161-1	91.000	113.870
BR2162-1	92.500	115.370
BR2163-1	94.000	116.870
BR2164-1	95.500	118.370
BR2165-1	97.000	119.870
BR2166-1	98.500	121.370
BR2167-1	100.000	122.870
BR2168-1	101.500	124.370
BR2169-1	103.000	125.870
BR2170-1	104.500	127.370
BR2171-1	106.000	128.870
BR2172-1	107.500	130.370
BR2173-1	109.000	131.870
BR2174-1	110.500	133.370
BR2175-1	112.000	134.870
BR2176-1	113.500	136.370
BR2177-1	115.000	137.870
BR2178-1	116.500	139.370
BR2179-1	118.000	140.870
BR2180-1	119.500	142.370
BR2181-1	121.000	143.870
BR2182-1	122.500	145.370
BR2183-1	124.000	146.870
BR2184-1	125.500	148.370
BR2185-1	127.000	149.870
BR2186-1	128.500	151.370
BR2187-1	130.000	152.870
BR2188-1	131.500	154.370
BR2189-1	133.000	155.870
BR2190-1	134.500	157.370
BR2191-1	136.000	158.870
BR2192-1	137.500	160.370
BR2193-1	139.000	161.870
BR2194-1	140.500	163.370
BR2195-1	141.000	164.870
BR2196-1	143.500	166.370
BR2197-1	144.000	167.870
BR2198-1	146.500	169.370

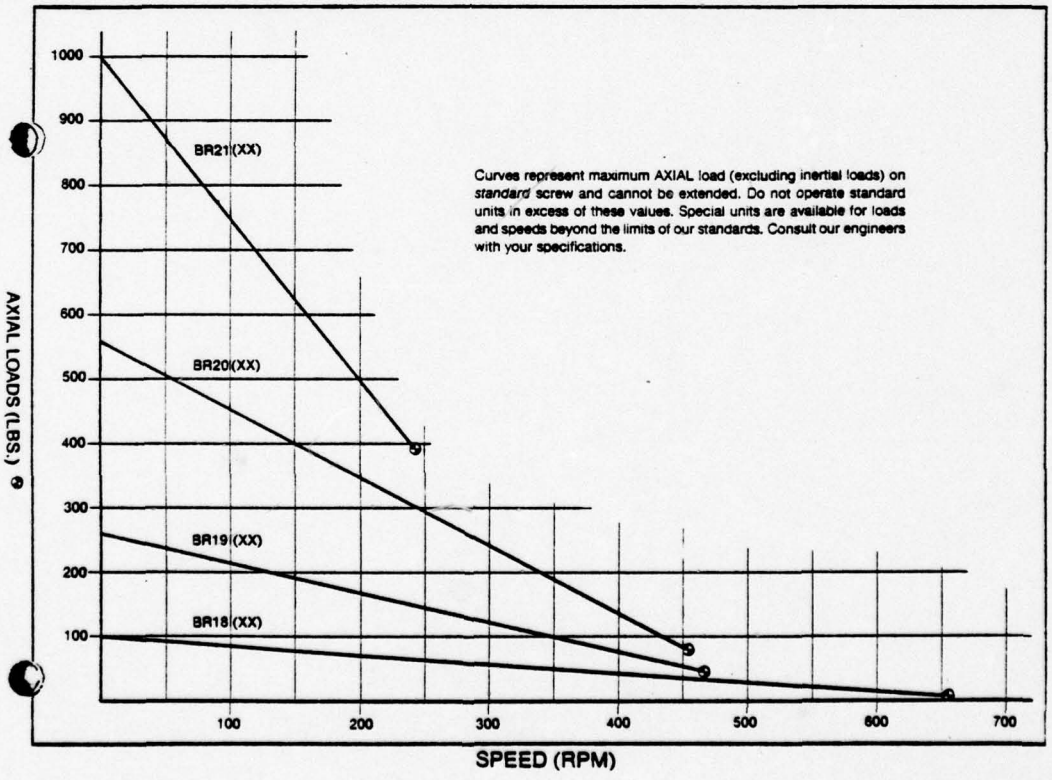
Lot numbers as well as part numbers must be shown on reorders.

Part No.	Shaft O.D.	Lead	Approximate Available End Material (B)	Nut Length (D)	Nut O.D. (E)	Bolt Circle (F)	Tap (G)	Nut Overtravel (H)	Screw Material
BRC1600	.375	.500	1.5	1.38	.98	.781	#6-32 UNC-2B	.74	17-4 pH
BRC1700	.500	.750	2.0	1.87	1.22	.937	#6-32 UNC-2B	1.00	17-4 pH
BR1800	.750	1.000	3.9	2.56	1.62	1.312	#8-32 UNC-2B	1.34	Alloy Steel
BR1900	1.250	1.250	6.1	4.13	2.37	1.937	1/4-20 UNC-2B	2.27	Alloy Steel
BR2000	1.750	2.000	7.8	5.00	3.25	2.687	5/16-18 UNC-2B	2.64	Alloy Steel
BR2100	2.500	3.000	7.8	6.87	4.47	3.750	7/16-20 UNF-2B	3.64	Alloy Steel

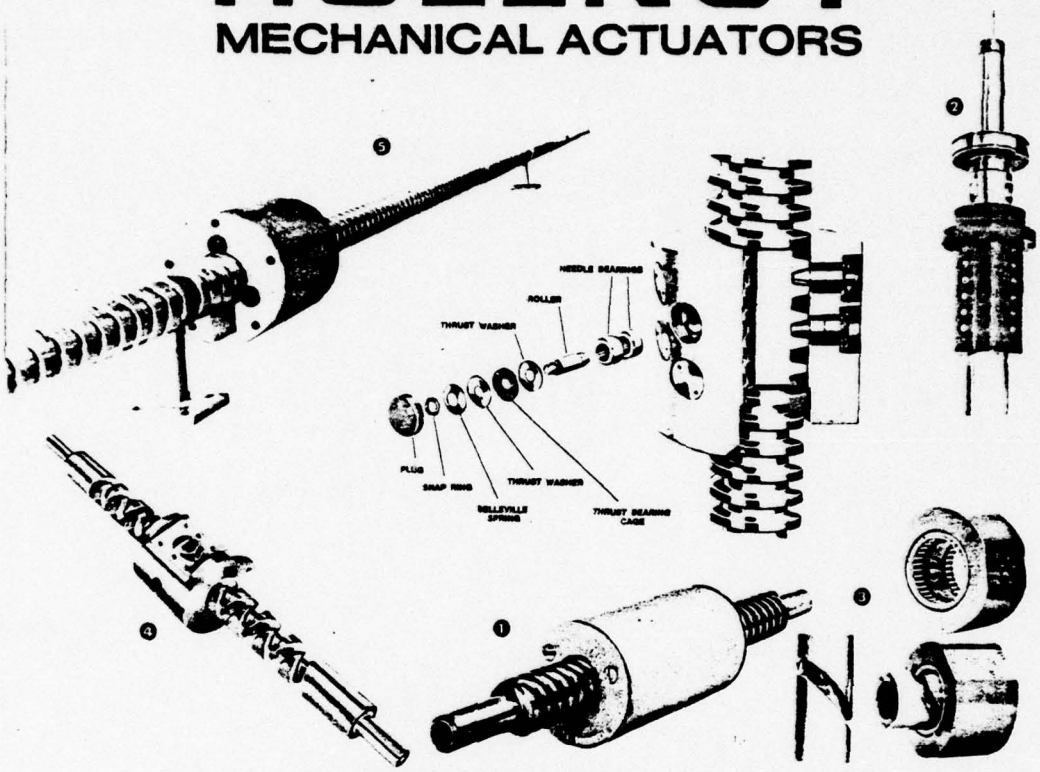
Curves represent maximum AXIAL load (excluding inertial loads) on *standard* screw and cannot be extended. Do not operate standard *units in excess of* these values. Special units are available for loads and speeds beyond the limits of our standards. Consult our engineers with your specifications.




A
B
C
D
H
E
F
G


1000
900
800
700
600
500
400
300
200
100
BR21(XX)
BR20(XX)
BR19(XX)
BR18(XX)
AXIAL LOADS (LBS.)
100
200
300
400
500
600
700
SPEED (RPM)
Curves represent maximum AXIAL load (excluding inertial loads) on *standard* screw and cannot be extended. Do not operate standard units in excess of these values. Special units are available for loads and speeds beyond the limits of our standards. Consult our engineers with your specifications.

ROLLNUT®
MECHANICAL ACTUATORS



❶ ROLLNUT Can operate at very high speeds, carry heavy loads—long lead/pitch units available (e.g. .812" shaft dia. with 2.250" lead). No loose parts. Housing may be removed from shaft in one piece. Zero backlash units available. Variable leads, right and left hand threads available on one shaft.

❷ SPLINE Capable of carrying heavy loads at high speeds with a minimum of friction and zero backlash.

❸ OSCILLATOR A single loop actuator, 1 cycle/revolution. Constant velocity or harmonic motion. Almost any velocity can be provided.

❹ REVERSER A diamond-threaded shaft and nut using rollers as load-carrying elements to reduce friction. Nut is self reversing. For heavy duty operations.

❺ LONG SPAN UNIT Slotted housing allows nut to pass over screw supports, reducing critical speed problems and screw diameter. Zero backlash available.

NORCO INC.

OFFICE: BOX 405, GEORGETOWN, CONN. 06829 TEL. (203) 544-8301 TWX 710 460 0593

IN EUROPE: NORCO LTD., INDUSTRIAL ESTATES, WATERFORD, IRELAND TWX 852 8672

Patents issued and pending in U.S.A. and principal countries.

LEBUS AUTOMATIC FLEET ANGLE COMPENSATOR SOLVES MOST FLEET ANGLE PROBLEMS

Experience has shown that the fleet angle (angle that the rope makes with the flange) should be kept below 1¼ degrees. Angles in excess of this will have an immediately adverse effect on spooling and shorten the service life of the rope.

Lebus has developed an Automatic Fleet Angle Compensator to function in conjunction with the Lebus Controlled Multi-layer Spooling. The device consists of an ordinary fleeting sheave free to rotate and slide on a shaft which is, in turn free to oscillate between eccentric centers. The movement of the sheave along the shaft is entirely motivated by the wire rope spooling on the drum and the tension in the rope causes the shaft to rotate on an eccentric so that the sheave moves in the path of an arc, therefore the fleet angle remains constant and workable.

There is no mechanical connection between the drum and the Fleet Angle Compensator apart from the rope itself.

In operation the Lebus Fleet Angle Compensator is COMPLETELY AUTOMATIC and after the initial adjustments are made at the time of installation and rope is spooled onto the drum, a minimum amount of inspection and maintenance is necessary. The Fleet Angle Compensator keeps the wire rope spooling perpendicular to axis of the drum at all times.

The Lebus Fleet Angle Compensator to function properly must have the following conditions:

1. The cable must go from the drum over the compensator sheave to a fixed point such as a fairlead or fixed sheave.
2. To avoid excessive angles of the rope on the sheaves the minimum distance between the fair lead and the sheave on the Fleet Angle Compensator must be at least four times the drum width.
3. The cable must have a minimum angle of contact with the Fleet Angle Compensator sheave of 60°.
4. The drum must have controlled spooling comparable to Lebus Spooling.
5. There must be sufficient tension on the cable during the spooling operation.

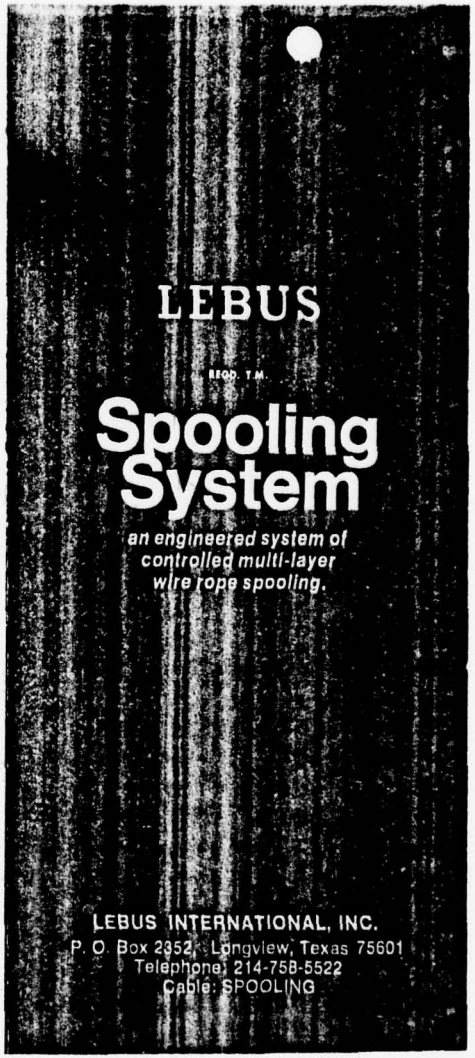


ADVANTAGES OF LEBUS AUTOMATIC FLEET ANGLE COMPENSATOR

- Compensates for excessive fleet angles to provide proper fleet angle for proper spooling on Lebus Grooved Drums or on grooved drums comparable to Lebus Grooving.
- No special synchronizing drive trains and controls required.
- Wear on rope is no greater than that from a simple sheave.
- The only maintenance requirements are proper lubrication of shaft and bearings.
- Can be mounted in any position around the drum.



Utility winch, note extreme fleet angle corrected by Lebus Automatic Fleet Angle Compensator.



SAFE! LEBUS Multi-layer spooling

WHAT IT IS

The Lebus System is an engineered method of controlling the spooling of wire rope on a winch drum so that there is no practical limit to the number of layers that can be spooled with safety irrespective of the severity of load and speed conditions, or the sizes of rope and drum.

HOW IT WORKS

This is done by providing a rope drum with special grooving and other features which, together, control the formation of the first layer of rope in a predetermined pattern that is reproduced on the second and all subsequent layers simply by ensuring that the drum flanges are parallel to each other and at right angles to the drum axis.

It will be seen from the drum development in Fig. 1 that the continuous groove is parallel to the flanges except for two crossover sections where the groove moves across the drum one half pitch to give a full pitch of movement per revolution.

At the flanges the rope is guided in a manner that will cause it to spool in a pyramidal pattern in the parallel sections of the second and subsequent layers (see Fig. 2) and to cross over two half pitches per revolution in the same radial positions as on the first layer.

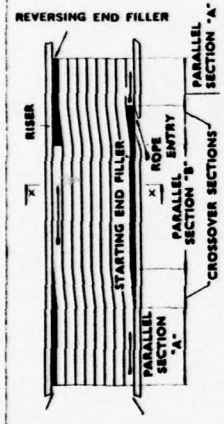


FIG. 1

Figs. 2 & 3 show in cross section how this is continued to the fourth layer.

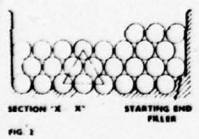


FIG. 2

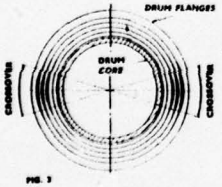


FIG. 3

ADVANTAGES OF LEBUS GROOVING

SAFETY

Multi-layering of steel wire rope can now be accomplished with safety, because cutting-in of a rope between neighboring coils of an underlying layer is impossible.

INCREASED ROPE LIFE

With the rope spooling controlled from flange to flange and layer by layer a uniform pattern is formed which will give the best possible conditions of loading between the coils, giving rise to the minimum of wear on the rope and thrust on flanges.

SPACE SAVING

By multi-layering it is possible to accommodate a considerable length of rope on a relatively small drum.

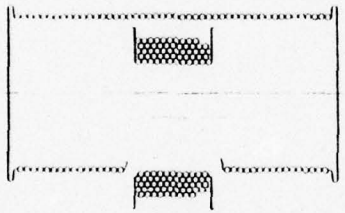
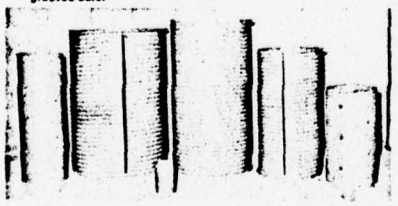
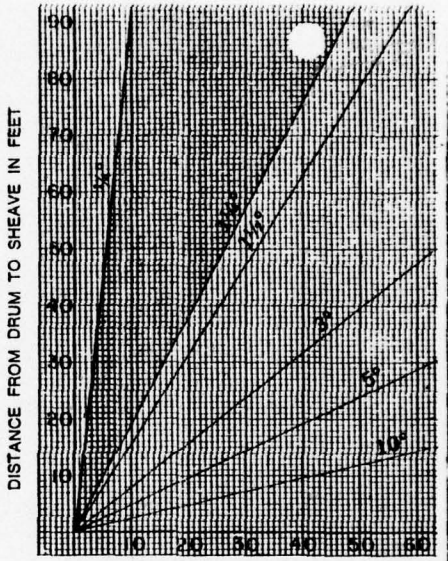


FIG. 4 Large drum 26" P.C.D. first layer × 60" long. Lebus grooved drum 19" P.C.D. first layer × 15½" long. Both accommodating 316' of 1" nominal diam. S.W. rope.

METHODS OF APPLICATION

Fitting a machined split sleeve or wrapper to an existing drum by bolting or welding. Machining the pattern direct on to a drum barrel or fit with individual grooved bars.



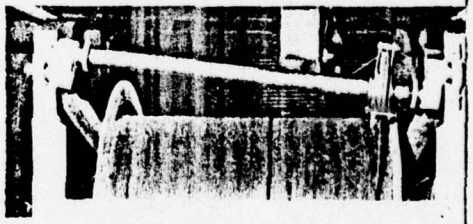


DISTANCE BETWEEN FLANGES IN INCHES

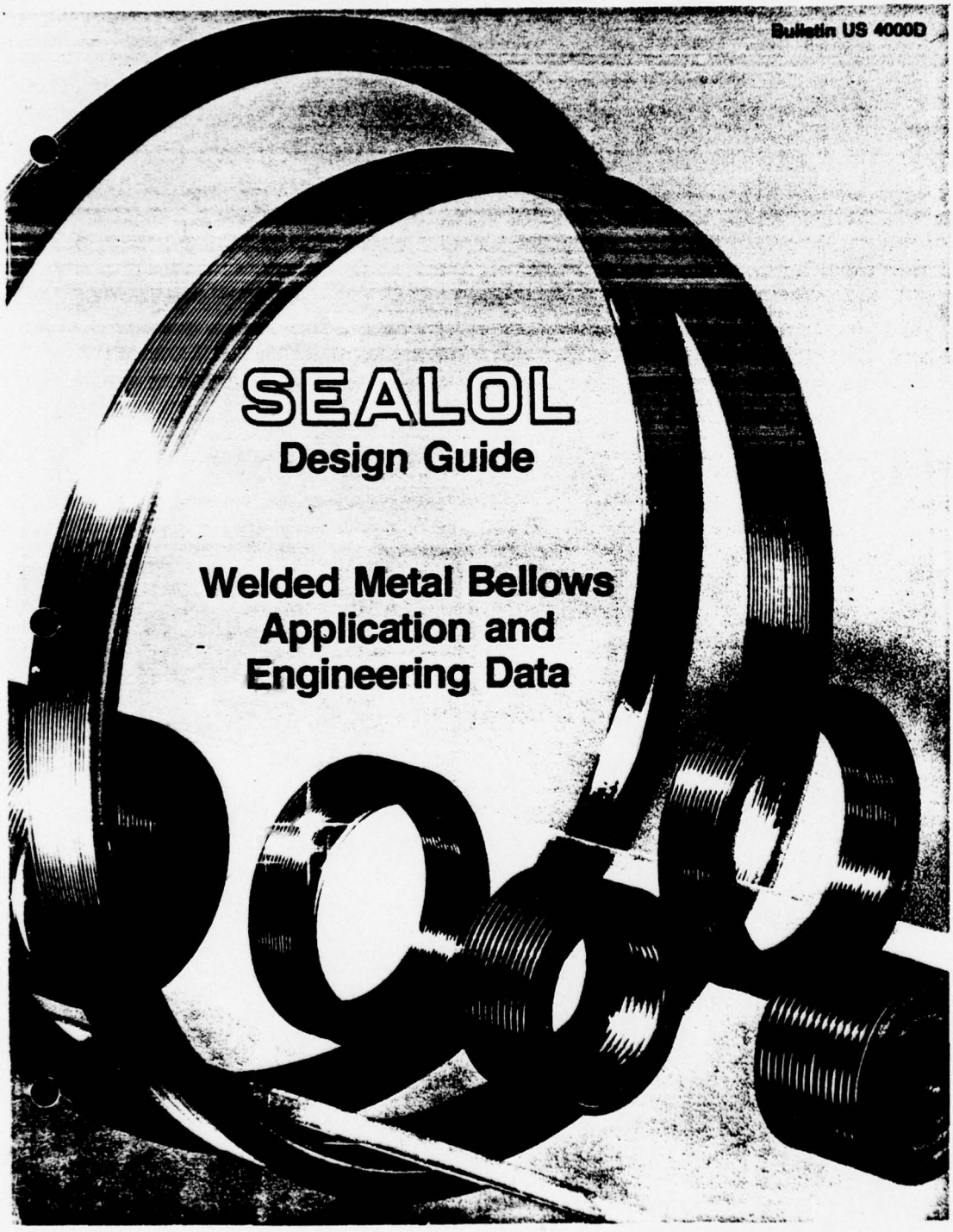
NOTE: Shaded area is proper range of fleet angle.

(Assume Sheave Is Located on Center Line of Drum)

WHY USE A FLEET ANGLE COMPENSATOR?



Sheave rotates and slides along eccentric oscillating shaft to keep wire rope perpendicular to the axis of the drum core. The sheave is actuated only by the cable spooling onto the drum.


Bulletin US 4000D
SEALOL
Design Guide
Welded Metal Bellows
Application and
Engineering Data

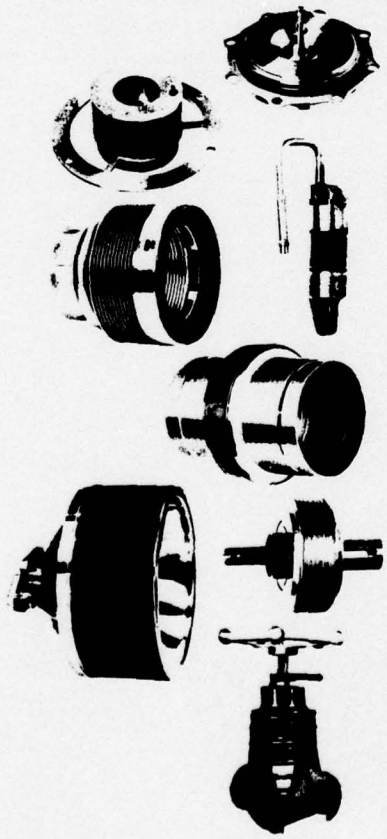
If you have an idea, SEALOL'S Welded Metal Bellows Could Help You Make It Work.

Now . . . let your imagination set the limits when you're developing new applications for flexible metal bellows.

Sealol can supply a welded metal bellows to meet virtually any size or performance specification. There's a large selection of stock sizes and materials to choose from *(see page 6)* **or Sealol can design and fabricate a bellows to fit your exact needs.**

This design guide is intended to help you understand the design factors which will determine the specifications of the bellows you need. By ***selecting a Sealol welded metal bellows, you'll have a bellows which*** **meets your specifications exactly, with no compromise in quality, strength or reliability.**

SEALOL Welded Metal Bellows for...



Pressure Sensing
Accurately controlled aneroids, converting pressure effects into calibrated movement.

Temperature Sensing
Converting temperature effects into calibrated movement *via expansion of a charge fluid.*

Hydraulic Operation
Conversion of hydraulics into mechanical work.

Hydraulic Accumulators
For storage of pressurized fluids, or to absorb pressure shocks.

Flexible Joints
For elimination of leakage or shock at joints subject to axial, angular and radial displacement.

Dynamic Seals
Elimination of leakage and wear as might occur in reciprocating shafts assembly.

Miscellaneous Controls
As in fuel regulators, pressure switches, expansion joints, and vibration joints.

Packless Valves
For zero leakage and total elimination of valve stem packing.

SEALOL Welded Metal Bellows

...offer important operating advantages compared with hydroform or rolled bellows. Greater cycle life, longer stroke and higher temperature capability mean a dependable bellows with a much longer service life.

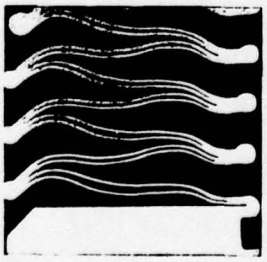
Construction Characteristics

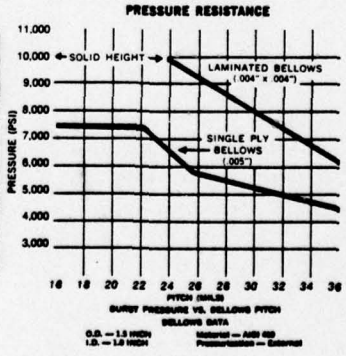
- consist of a series of precision, washer-like plates welded at the I.D. and O.D. to form convolutions.
- maintain extremely accurate dimensional and performance tolerances because each plate is individually die-formed.
- fabricated in plate thicknesses that cover the range of .0015" to .015" with bellows diameters as small as $^3/_{16}$" to two feet or more.
- meet the most stringent weld requirements — meet or exceed Mil-T-5021C, RDT F6-5T and XWS16424.
- *can be fabricated to yield extremely high strength for high pressure* applications (to 10,000 psi).
- capable of withstanding temperature extremes of near absolute zero to +1,800°F.
- permit a wide range of desired parameters to be built into a particular unit.

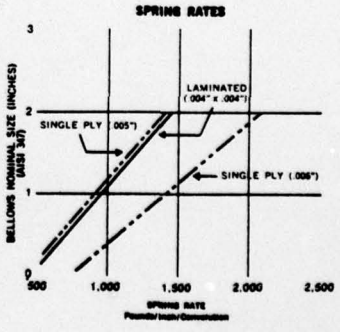
For High Pressures
SEALOL Laminated* Welded Metal Bellows

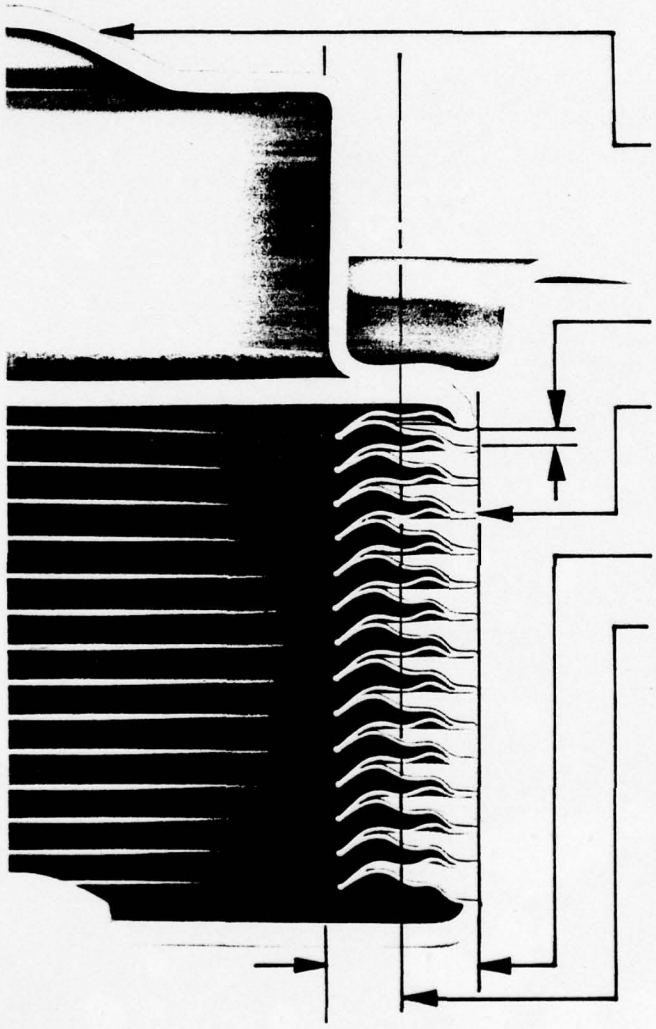
laminated welded metal bellows are capable of withstanding internal and external pressures to 10,000 psi. This is done without degrading the desirable operating characteristics such as low spring rate and high stroke-to-free-length ratio.

U.S. Patent No. 3090403









END FITTINGS

All end fittings must be of weldable material. However, they do not have to be of the same material as the bellows plates. The weld lip must approximate the thickness of the plate for even heat absorption and proper fusion of materials. Welding is performed by inert gas shielded arc process.

PITCH

Axial dimension from one convolution to corresponding point on next convolution.

PLATE

Individual metallic element within a bellows.

CONVOLUTION

Any two plates welded together at either the I.D. or O.D.

SPAN

Radial dimension of bellows plate.

EFFECTIVE DIAMETER

Imaginary diameter at approximate center of bellows span that corresponds to a piston diameter. Effective diameter approximation =

$$\frac{\text{O.D.} + \text{I.D.}}{2}$$

EFFECTIVE AREA

$$\text{Approximation} = \frac{\pi}{4} \times \left(\frac{\text{O.D.} + \text{I.D.}}{2} \right)^2$$

MATERIALS

All weldable materials including 300 and 400 series stainless steels, AM-350, Inconels, Monel, Ni-Span C, pure titanium, Hastelloy.

Proper Design Parameters

The following are basic operational conditions and requirements that must be considered in designing a bellows device.

1. Cycle Life — The required cycle life dictates the maximum allowable design stress levels and along with pressure determines the plate thickness, span, width, etc. *(used in Nomagram calculation; see page 5)*

2. Motion — The movement of one end of the bellows in relation to the other in terms of axial, radial and angular displacement. This is expressed as deflection per convolution. *(used in Nomagram calculation; see page 5)*

3. Pressure — An important consideration in selecting material thickness, number of convolutions and operating length. *(used in Nomagram calculation; see page 5)*

4. Media and Temperature — Prime factors in material selection.

5. Envelope — The allowable operating envelope is usually determined by the end use of the bellows device. Considerations are available space, volumetric displacement, effective diameter, O.D. and I.D. clearance allowances, etc.

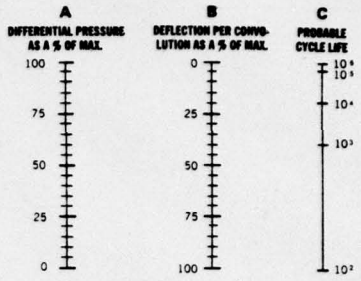
6. Pitch — The maximum pitch should not exceed the deflection as determined by the nomogram on page 5 plus the minimum or nested pitch. *The latter value is equivalent to three times the plate thickness.*

7. Vibration and Damping — Environmental vibration effects can be minimized by designing the bellows with a natural frequency different from the environment. Additional damping techniques include spring type coulomb dampers and hydraulic (viscous) damping methods.

8. Additional Considerations — Spring rate, effective area and volumetric efficiency are often inter-related and must be considered with the design characteristics discussed above.

Pressure Deflection Cycle Life Nomogram

With the following nomogram, it is relatively easy to determine pressure, deflection or cycle life for a given bellows configuration.



How It Works —

1. Select bellows plate material, thickness and I.D.:
   Plate Material — use either AM 350, 347SS or Inconel X-750
   Plate Thickness — use either .004", .005" or .006"
   Bellows I.D. — to determine bellows I.D. use the following —
   If O.D. is ¾" to 3", I.D. will be O.D. minus .500"
   If O.D. is 3⅛" to 3½", I.D. will be O.D. minus .600"
   If O.D. is 3⅝" to 4¾", I.D. will be O.D. minus .650"
2. Determine maximum (or 100%) pressure capability for above materials selection using the following formula:

$$100\%\ P = K \times \frac{\text{Plate Thickness}}{\text{Bellows I.D.}} \times 10^3$$

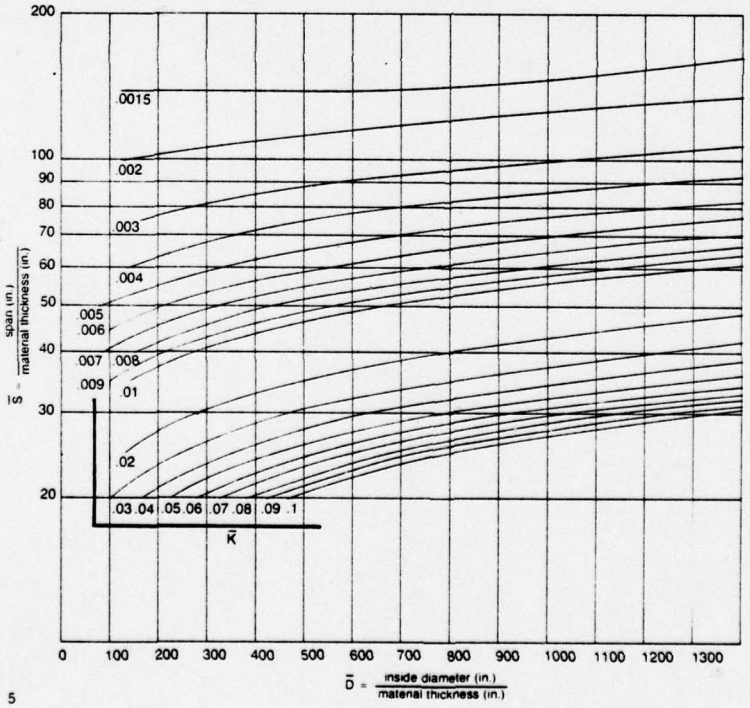
   K = 150 for AM 350
   K = 75 for 347SS
   K = 115 for Inconel X-750

3. Using the figure developed in 2. above as 100%, locate the pressure your application calls for on Scale A. This is done by converting your application pressure to a per cent of maximum pressure, i.e. divide application pressure by maximum pressure, then multiply by 100.
4. Determine maximum (or 100%) deflection per convolution using the following table.

	Bellows I.D.		
	to 2⅜"	2½"-2¾"	2⅞"-4"
AM350	.100	.115	.130
347SS	.035	.040	.045
Inconel X-750	.065	.075	.085

5. Using the figure developed in 4. as 100%, locate the desired deflection per convolution on Scale B. This is done by converting the desired deflection to a percent of maximum deflection, i.e. divide desired deflection by maximum deflection, then multiply by 100.
6. Connect the points located on Scale A and Scale B; extend the line to Scale C and you will have the probable cycle life.

   This nomogram can also be used to determine pressure or deflection. The only requirement, of course, is that two of the three variables must be known.



To Determine Spring Rates for Sealol Welded Metal Bellows

$$\text{Spring Rate } \frac{\text{(lbs.)}}{\text{in.}} = \frac{\bar{K}Et}{n}$$

where:

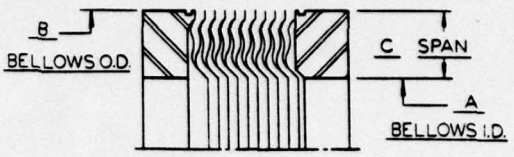
$\bar{K}$ = dimensionless spring rate — determine from plot on graph of $\bar{S}$ vs $\bar{D}$.

E = Young's Modulus (lbs./in.²) — the modulus of elasticity of the bellows material.

t = bellows material thickness (in.)

n = number of bellows convolutions.

SEALOL
Welded Metal Bellows



Tooling is available for the following sizes:

A I.D.	B O.D.	C Span	Effective Area (in²)
.125	.500	.187	.077
.187	.625	.218	.129
.245	.745	.250	.192
.250	.600	.175	.142
.250	.750	.250	.196
.312	.812	.250	.248
.341	.750	.205	.234
.341	.740	.200	.229
.400	.650	.125	.216
.433	.803	.185	.300
.437	.937	.250	.371
.450	.750	.150	.283
.470	1.346	.438	.647
.470	1.470	.500	.739
.477	.814	.1685	.327
.492	.840	.174	.348
.500	1.000	.250	.442
.553	1.029	.238	.491
.562	1.062	.250	.518
.562	1.562	.500	.885
.610	.960	.175	.484
.618	*.937*	*.1595*	*.475*
.687	1.187	.250	.688
.700	1.035	.167	.591
.750	1.120	.185	.685
.750	1.125	.187	.690
.750	1.250	.250	.785
.812	1.187	.1875	.784
.812	1.281	.2345	.860
.812	1.312	.250	.886
.820	1.620	.400	1.169
.825	1.605	.390	1.159
.896	1.246	.175	.900
.900	1.300	.200	.950
.937	1.812	.438	1.483
.937	1.437	.250	1.105
.937	1.989	.526	1.680
.960	1.300	.170	1.003
.970	1.710	.370	1.408
.982	1.322	.170	1.042
1.000	1.500	.250	1.227
1.000	1.750	.375	1.485
1.060	1.410	.175	1.198
1.062	1.562	.250	1.352
1.100	1.500	.200	1.327
1.120	1.500	.190	1.347
1.187	1.562	.187	1.483
1.187	1.687	.250	1.619
1.230	1.620	.195	1.594
1.281	1.656	.1875	1.690
1.284	1.728	.222	1.778
1.312	1.812	.250	1.913
1.392	1.812	.210	2.012
1.406	2.000	.297	2.277
1.415	2.210	.3975	2.579
1.437	1.937	.250	2.231
1.500	2.000	.250	2.405
1.525	2.000	.238	2.441
1.562	2.062	.250	2.578
1.580	2.174	.297	2.766
1.640	2.070	.215	2.702
1.637	2.187	.250	2.942
1.688	2.740	.526	3.849
1.750	2.250	.250	3.141
1.750	2.550	.400	3.630
1.750	2.750	.500	3.975
1.806	2.500	.347	3.640
1.800	3.450	.825	5.410
1.812	2.312	.250	3.339
1.841	2.437	.298	3.593
1.875	2.625	.375	3.975
1.926	2.380	.227	3.640
1.937	2.437	.250	3.754
1.980	*2.480*	*.250*	3.905
2.060	3.240	.590	5.514
2.062	2.406	.172	3.919
2.062	2.562	.250	4.191
2.150	3.650	.750	6.604
2.187	2.687	.250	4.663
2.275	3.025	.375	5.514
2.310	2.750	.220	5.026
2.312	2.812	.250	5.154
2.378	3.594	.608	7.001
2.380	3.500	.560	6.787
2.400	2.750	.175	5.206
2.437	2.937	.250	5.669
2.593	3.187	.297	6.558
2.614	3.100	.243	6.409
2.718	3.312	.297	7.138
2.735	3.187	.226	6.884
2.740	3.312	.286	7.190
2.750	3.250	.250	7.067
2.761	4.183	.711	9.465
2.812	3.312	.250	7.362
2.815	3.515	.350	7.866
2.843	3.437	.297	7.742
2.874	3.468	.287	7.895
2.968	3.625	.328	8.533
3.054	3.540	.243	8.535
3.093	3.750	.328	9.192
3.100	3.600	.250	8.812
3.218	3.875	.328	9.876
3.343	4.000	.328	10.584
3.344	3.830	.243	10.103
3.375	4.031	.328	10.767
3.468	4.125	.328	11.317
3.550	4.920	.685	14.083
3.593	4.250	.328	12.075
3.718	4.375	.328	12.857
3.730	4.230	.250	12.438
3.750	5.250	.750	15.900
3.843	4.500	.328	13.664
3.900	4.300	.200	13.199
3.968	4.625	.328	14.495
4.062	4.937	.437	15.897
4.090	4.590	.250	14.790
4.093	4.750	.328	15.350
4.220	5.250	.515	17.642
4.490	4.990	.250	17.642
4.500	4.900	.200	17.345
4.812	5.469	.328	20.749
5.125	5.875	.375	23.752
5.380	6.650	.635	28.409
5.600	6.100	.250	26.872
5.875	6.375	.250	29.457
6.050	7.000	.475	33.430
6.125	7.125	.500	34.463
6.200	6.700	.250	32.666
6.219	6.875	.328	33.656
6.500	7.156	.328	36.607
6.625	7.625	.500	39.861
6.875	7.375	.250	39.861
6.942	8.442	.750	46.458
7.200	8.000	.400	45.353
7.500	8.250	.375	48.695
7.750	9.000	.625	55.074
8.280	8.780	.250	57.132
8.890	9.890	.500	69.233
9.375	10.175	.400	75.026
9.437	10.437	.500	77.534
9.526	10.526	.500	78.929
9.660	10.312	.323	78.300
11.575	12.375	.400	112.598
16.000	17.000	.500	213.770
17.000	19.000	1.000	254.405
19.750	23.000	1.625	358.750
21.000	23.000	1.000	380.037

CUSTOM SIZES
Available in any weldable material to meet your exact requirements. Please contact Sealol for further information.

Make your own data sheets with this
COPY MACHINE MASTER

SEALOL
Welded Metal Bellows Application Data Sheet

Date

Your Name Title

Company

Address

City State Zip Tel.

To: SEALOL, INC.
100 Pioneer Ave.
Warwick, R.I. 02888

Please furnish your recommendations for the following application:

Have you already used a bellows for this application?

If yes and the results were not satisfactory, why not?

Operating pressure:

Internal PSI External PSI

Proof pressure:

Internal PSI External PSI

Temperature: Normal Max. Min. °F

Media: Internal

External

Stroke: Inches Frequency: CPM

Effective Area Sq. Inches Cycle Life

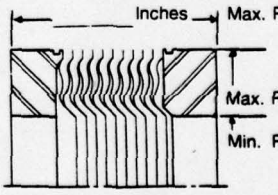
Volumetric Displacement: Cubic Inches

Desired Spring Rate

Bellows Package Requirements

☐ A layout drawing is attached. Please be sure that the dimensions shown here are indicated.

☐ Layout dimensions are indicated below.

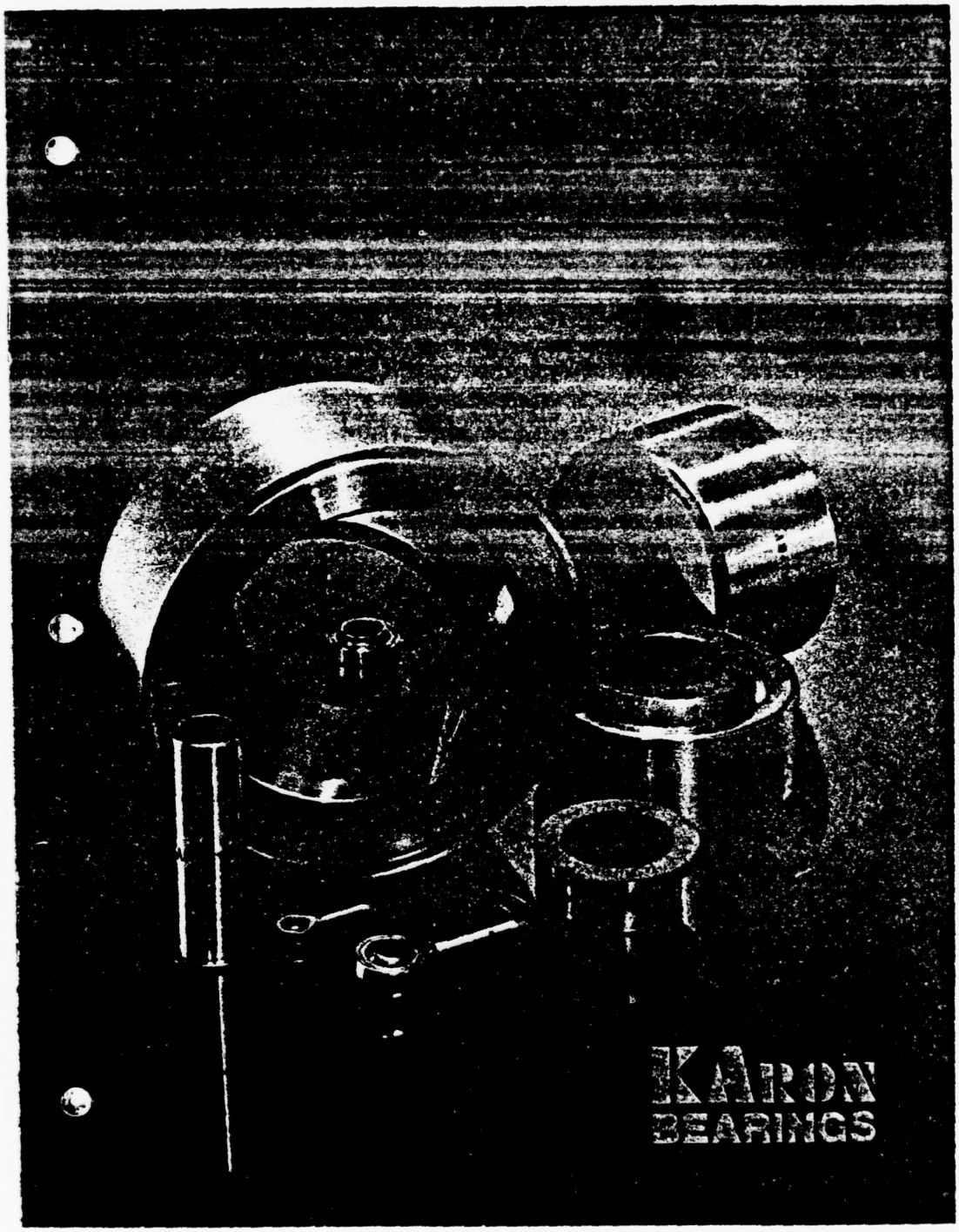


THE SEALOL GROUP
AN COMPANY
SEALOL, INC. • CHEMPRO, INC. • ROTARY SEAL CORPORATION

Warwick, Rhode Island 02888
Phone (401) 781-4700

Copyright 1975 Sealol Inc
Printed in U S A

RA #5048 750550


KARON
BEARINGS

KARON from

FEATURES

- Minimal Liner Wear
- Self Lubrication
- 100% Liner to Ball Conformity
- Zero Backlash
- Low Predictable Torque
- Excellent Corrosion Resistance
- Reduced Liner Deflection

BENEFITS

- Extended Life
- No Maintenance
- Superior Performance
- Low Cost

KAMATICS Corporation

CONCEPT

The KARON bearing system is generated by swaging a metallic sleeve around a spherical ball creating a non-uniform cavity between the sleeve and ball. Fig. 1A. The KARON material is then injected into this cavity, conforming 100% to the ball while bonding itself to the sleeve. Fig. 1B. Through the use of a non-uniform cavity, a mechanical lock is created ensuring liner retention.

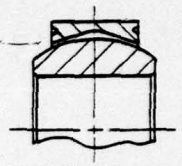


Fig. 1A.

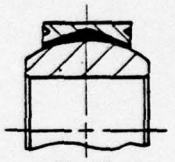


Fig. 1B.

CHARACTERISTICS OF THE KARON LINER

The success of this product is attributed to the characteristics of the KARON material which forms the liner. It exhibits low friction and excellent resistance to wear. It is molded around the ball using injection techniques resulting in perfect conformity, further aiding resistance to wear. By molding, rather than swaging during the final manufacturing operation, internal clearances are closely controlled yielding low predictable breakaway torque and zero backlash.

Conventional bonded fabric bearings require swaging as a final operation which, due to its inherent sensitivity, can result in erratic conformity. This condition generates high localized pressures thereby accelerating wear and reducing bearing life.

The KARON liner meets or exceeds all the performance parameters of MIL-B-81820 and is qualified to this specification. See Page 15 for appropriate type selection for specific requirements.

PART NUMBERING SYSTEM

Basic Part Number

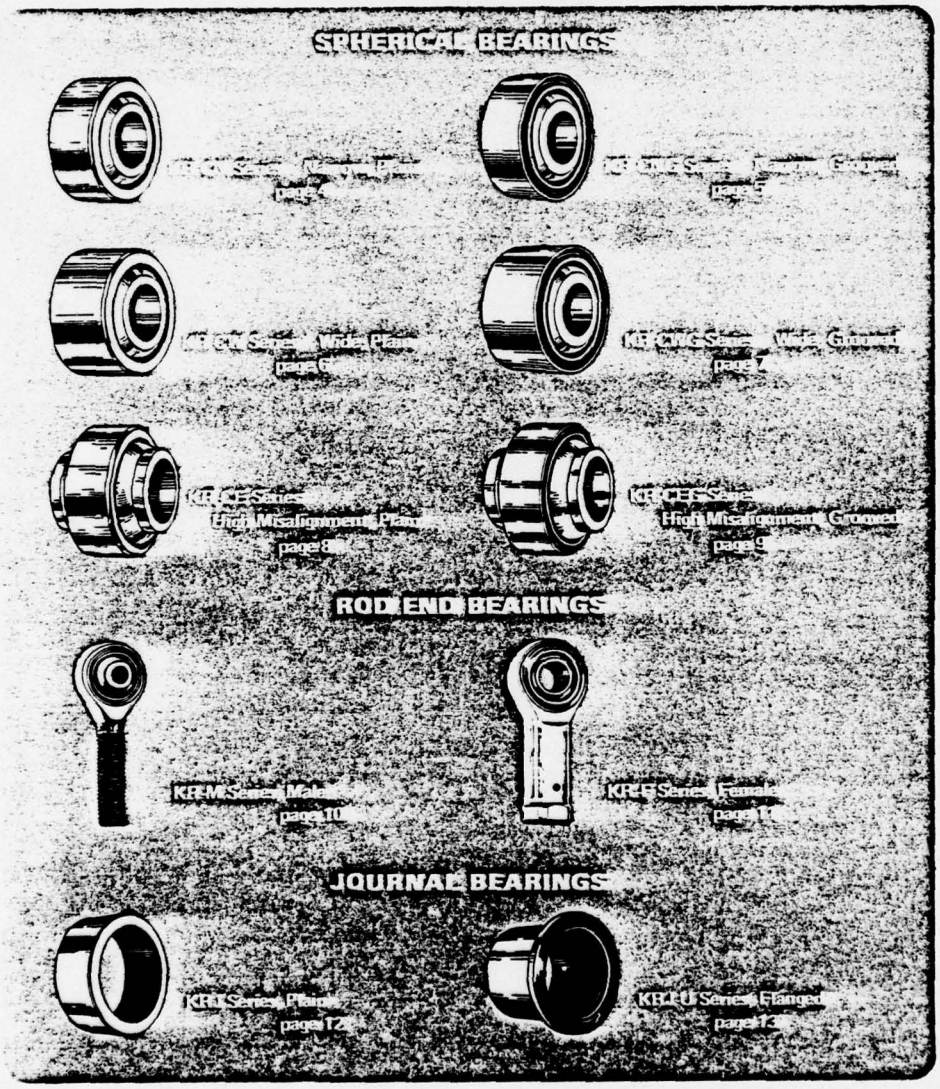
SYMBOL	SIGNIFIES
KR	KARON SPHERICAL SERIES
KRJ	KARON JOURNAL SERIES
3 thru 20	DESIGNATES SIZE OF BORE IN 1/16"
C	CARTRIDGE
M	MALE ROD END
F	FEMALE ROD END
W	WIDE SERIES
N	NARROW SERIES
G	GROOVED LIPS
E	HIGH MISALIGNMENT
U	FLANGE
UD	COATED FLANGE
Z	SEALS
Y	ALUMINUM
B,VorH	LINER DESIGNATION

Ordering Information

PART NUMBER = BASIC NUMBER + S L K [B,VorH]

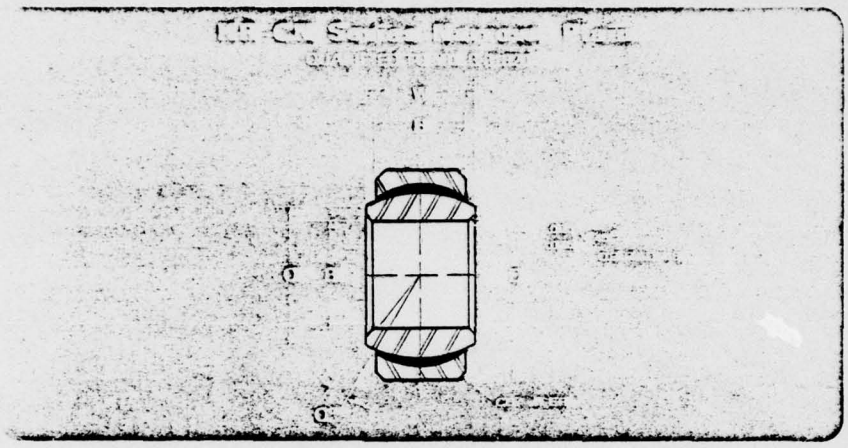
- B,VorH — Liner Designation See Page 15
- K — Keyway. Add K when required
- L — Left Hand Thread. Add L when required
- S — Body Material. Add S for 17-4PH; Add A for Alloy Steel; Add Y for Aluminum
- BASIC NUMBER — See Individual Tables on Pages 4 thru 13

KARON® BEARINGS*



U.S. Patent Nos. 3,808,216; 3,904,731; others pending.

KARON SPHERICAL BEARINGS

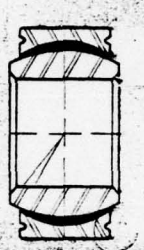


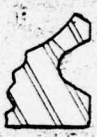
MS 14104	B	D	W	H	O				Q°			
BEARING NUMBERS	BORE DIA +.0000 −.0005	OUTSIDE DIA +.0000 −.0005	BALL WIDTH +.000 −.002	RACE WIDTH +.005 −.005	SHOULDER DIA MIN	BALL DIA REF	CHAMFER X 45°	RADIAL DYNAMIC LOAD RATINGS (LBS.)	APPROX. MISALIGN-MENT	STATIC LIMIT LOAD RADIAL (LBS.)	STATIC LIMIT LOAD AXIAL (LBS.)	APPROX. WEIGHT (LBS.)
KR3-CN	.1900	.5625	.281	.218	.293	.406	.010 / .020	1,500	10°	3,975	150	.02
KR4-CN	.2500	.6562	.343	.250	.364	.500		3,320	10°	6,040	430	.02
KR5-CN	.3125	.7500	.375	.281	.419	.562		5,460	10°	8,750	700	.03
KR6-CN	.3750	.8125	.406	.312	.475	.625	.020 / .030	6,600	9°	10,540	1,100	.04
KR7-CN	.4375	.9062	.437	.343	.530	.687		8,050	8°	13,200	1,400	.05
KR8-CN	.5000	1.0000	.500	.390	.600	.781		10,400	8°	17,900	2,100	.07
KR9-CN	.5625	1.0937	.562	.437	.670	.875		13,000	8°	23,200	3,680	.09
KR10-CN	.6250	1.1875	.625	.500	.739	.963		16,450	8°	30,500	4,720	.12
KR12-CN	.7500	1.4375	.750	.593	.920	1.187	.030 / .040	23,600	8°	46,400	6,750	.21
KR14-CN	.8750	1.5625	.875	.703	.980	1.312		30,250	8°	62,200	9,350	.27
KR16-CN	1.0000	1.7500	1.000	.797	1.118	1.500		38,000	9°	82,200	12,160	.39
KR20-CN	1.2500	2.0000	1.093	.942	1.406	1.781		52,100	6°	108,000	15,500	.53

BEARING MATERIALS		
	MATERIAL	HARDNESS (MIN.)
OUTER RING	AMS5643 (17-4PH)	28 Rc
BALL	AMS5630 (440C)	55 Rc
LINER	KARON	N/A

BEARING SIZE	NO LOAD BREAKAWAY TORQUE (IN LBS.)
3 & 4	0 – 5
5 thru 12	0 – 15
14 thru 20	0 – 24

KARON SPHERICAL BEARINGS





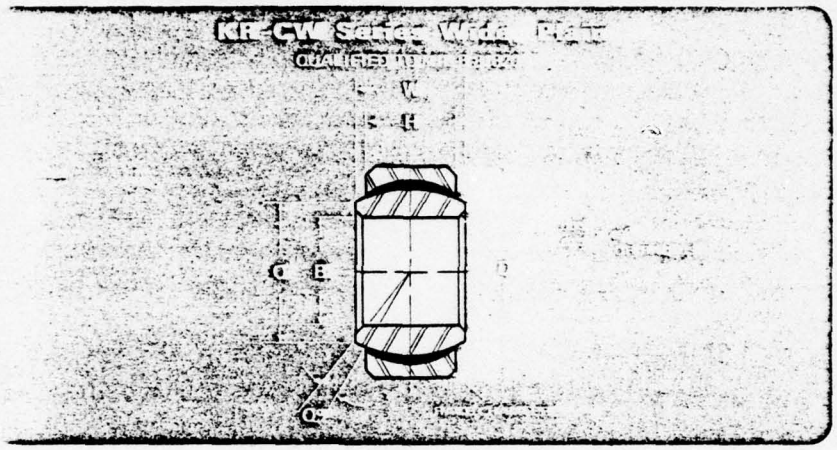
SIZES	P +.000 −.015	R +.000 −.010	S MIN.	Y°
3 & 4	.030	.015	.010	20°
5 thru 7	.040	.020	.020	30°
8 thru 20	.060	.020	.020	30°

MS 14101	B	D	W	H	O		E		Q°			
BEARING NUMBERS	BORE DIA +.0000 −.0005	OUTSIDE DIA +.0000 −.0005	BALL WIDTH +.000 −.002	RACE WIDTH +.005 −.005	SHOULDER DIA MIN	BALL DIA REF	GROOVE DIA +.000 −.010	RADIAL DYNAMIC LOAD RATINGS (LBS.)	APPROX. MISALIGN-MENT	STATIC LIMIT LOAD RADIAL (LBS.)	STATIC LIMIT LOAD AXIAL (LBS.)	APPROX. WEIGHT (LBS.)
KR3-CNG	.1900	.5625	.281	.218	.293	.406	.502	1,500	10°	3,975	150	.02
KR4-CNG	.2500	.6562	.343	.250	.364	.500	.596	3,320	10°	6,040	430	.02
KR5-CNG	.3125	.7500	.375	.281	.419	.562	.662	5,460	10°	8,750	700	.03
KR6-CNG	.3750	.8125	.406	.312	.475	.625	.714	6,600	9°	10,540	1,100	.04
KR7-CNG	.4375	.9062	.437	.343	.530	.687	.808	8,050	8°	13,200	1,400	.05
KR8-CNG	.5000	1.0000	.500	.390	.600	.781	.878	10,400	8°	17,900	2,100	.07
KR9-CNG	.5625	1.0937	.562	.437	.670	.875	.972	13,000	8°	23,200	3,680	.09
KR10-CNG	.6250	1.1875	.625	.500	.739	.963	1.065	16,450	8°	30,500	4,720	.12
KR12-CNG	.7500	1.4375	.750	.593	.920	1.187	1.315	23,600	8°	46,400	6,750	.21
KR14-CNG	.8750	1.5625	.875	.703	.980	1.312	1.440	30,250	8°	62,200	9,350	.27
KR16-CNG	1.0000	1.7500	1.000	.797	1.118	1.500	1.628	38,000	9°	82,200	12,160	.39
KR20-CNG	1.2500	2.0000	1.093	.942	1.406	1.781	1.878	52,100	6°	108,000	15,500	.53

BEARING MATERIALS		
	MATERIAL	HARDNESS (MIN.)
OUTER RING	AMS5643 (17-4PH)	28 Rc
BALL	AMS5630 (440C)	55 Rc
LINER	KARON	N/A

BEARING SIZE	NO LOAD BREAKAWAY TORQUE (IN LBS.)
3 & 4	0 – 5
5 thru 12	0 – 15
14 thru 20	0 – 24

KARON SPHERICAL BEARINGS

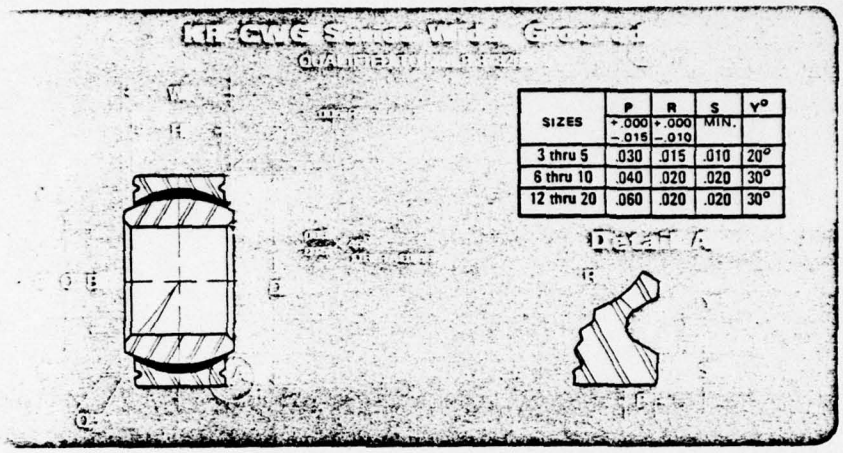


MS 14102	B	D	W	H	O				Q°			
BEARING NUMBERS	BORE DIA +.0000 −.0005	OUTSIDE DIA +.0000 −.0005	BALL WIDTH +.000 −.002	RACE WIDTH +.005 −.005	SHOULDER DIA MIN.	BALL DIA REF	CHAMFER X 45°	RADIAL DYNAMIC LOAD RATINGS (LBS.)	APPROX. MISALIGN-MENT	STATIC LIMIT LOAD RADIAL (LBS.)	STATIC LIMIT LOAD AXIAL (LBS.)	APPROX. WEIGHT (LBS.)
KR3-CW	.1900	.6250	.437	.327	.300	.531	.015 / .025	4,900	15°	9,000	1,770	.03
KR4-CW	.2500	.6250	.437	.327	.300	.531		4,900	15°	9,000	1,770	.03
KR5-CW	.3125	.6875	.437	.317	.360	.562		6,050	14°	9,400	1,640	.04
KR6-CW	.3750	.8125	.500	.406	.466	.687	.020 / .030	8,310	8°	13,700	2,630	.06
KR7-CW	.4375	.9375	.562	.442	.537	.781		11,750	10°	20,700	3,650	.08
KR8-CW	.5000	1.0000	.625	.505	.607	.875		14,950	9°	27,500	4,970	.10
KR9-CW	.5625	1.1250	.687	.536	.721	1.000		18,100	10°	34,400	5,370	.14
KR10-CW	.6250	1.1875	.750	.567	.747	1.062		20,250	12°	39,000	6,130	.16
KR12-CW	.7500	1.3750	.875	.630	.845	1.216	.030 / .040	26,200	13°	52,300	7,730	.24
KR14-CW	.8750	1.6250	.875	.755	.995	1.375		33,600	6°	67,300	10,800	.35
KR16-CW	1.0000	2.1250	1.375	1.005	1.269	1.875		56,250	12°	137,000	19,300	.97
KR20-CW	1.2500	2.3750	1.500	1.130	1.460	2.093		65,900	14°	153,000	21,400	1.10

BEARING MATERIALS		
	MATERIAL	HARDNESS (MIN.)
OUTER RING	AMS5643 (17-4PH)	28 Rc
BALL	AMS5630 (440C)	55 Rc
LINER	KARON	N/A

BEARING SIZE	NO LOAD BREAKAWAY TORQUE (IN LBS.)
3 & 4	0 – 5
5 thru 12	0 – 15
14 thru 20	0 – 24

KARON SPHERICAL BEARINGS



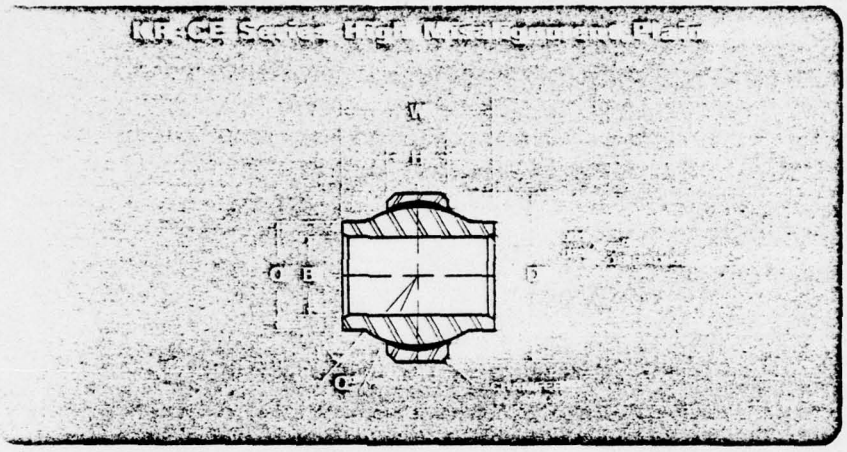
SIZES	P +.000 −.015	R +.000 −.010	S MIN.	Y°
3 thru 5	.030	.015	.010	20°
6 thru 10	.040	.020	.020	30°
12 thru 20	.060	.020	.020	30°

MS 14103	B	D	W	H	Q		E		Q°			
BEARING NUMBERS	BORE DIA +.0000 −.0005	OUTSIDE DIA +.0000 −.0005	BALL WIDTH +.000 −.002	RACE WIDTH +.005 −.005	SHOULDER DIA MIN	BALL DIA REF	GROOVE DIA +.000 −.010	RADIAL DYNAMIC LOAD RATINGS (LBS.)	APPROX. MISALIGN-MENT	STATIC LIMIT LOAD RADIAL (LBS.)	STATIC LIMIT LOAD AXIAL (LBS.)	APPROX. WEIGHT (LBS.)
KR3-CWG	.1900	.6250	.437	.327	.300	.531	.565	4,900	15°	9,000	1,770	.03
KR4-CWG	.2500	.6250	.437	.327	.300	.531	.565	4,900	15°	9,000	1,770	.03
KR5-CWG	.3125	.6875	.437	.317	.360	.593	.627	6,050	14°	9,400	1,640	.04
KR6-CWG	.3750	.8125	.500	.406	.466	.687	.714	8,310	8°	13,700	2,630	.06
KR7-CWG	.4375	.9375	.562	.442	.537	.781	.839	11,750	10°	20,700	3,650	.08
KR8-CWG	.5000	1.0000	.625	.505	.607	.875	.902	14,950	9°	27,500	4,970	.10
KR9-CWG	.5625	1.1250	.687	.536	.721	1.000	1.027	18,100	10°	34,400	5,370	.14
KR10-CWG	.6250	1.1875	.750	.567	.747	1.062	1.089	20,250	12°	39,000	6,130	.16
KR12-CWG	.7500	1.3750	.875	.630	.845	1.250	1.253	26,200	13°	52,300	7,730	.24
KR14-CWG	.8750	1.6250	.875	.755	.995	1.375	1.503	33,600	6°	67,300	10,800	.35
KR16-CWG	1.0000	2.1250	1.375	1.005	1.269	1.875	2.003	56,250	12°	137,000	19,300	.97
KR20-CWG	1.2500	2.3750	1.500	1.130	1.460	2.093	2.253	65,900	14°	153,000	21,400	1.10

BEARING MATERIALS		
	MATERIAL	HARDNESS (MIN.)
OUTER RING	AMS5643 (17-4PH)	28 Rc
BALL	AMS5630 (440C)	55 Rc
LINER	KARON	N/A

BEARING SIZE	NO LOAD BREAKAWAY TORQUE (IN LBS.)
3 & 4	0 – 5
5 thru 12	0 – 15
14 thru 20	0 – 24

KARON SPHERICAL BEARINGS with EXTENDED INNER RACE



BEARING NUMBERS	B BORE DIA +.0000 −.0005	D OUTSIDE DIA +.0000 −.0005	W BALL WIDTH +.000 −.002	H RACE WIDTH +.005 −.005	O SHOULDER DIA MIN	BALL DIA REF	CHAMFER X 45°	RADIAL DYNAMIC LOAD RATINGS (LBS.)	α° APPROX. MISALIGN-MENT	STATIC LIMIT LOAD RADIAL (LBS.)	STATIC LIMIT LOAD AXIAL (LBS.)	APPROX. WEIGHT (LBS.)
KR3-CE	.1900	.5625	.500	.205	.319	.437	.010 / .020	2,720	15°	3,740	380	.03
KR4-CE	.2500	.7400	.593	.255	.390	.593		4,420	25°	7,400	560	.04
KR5-CE	.3125	.6875	.625	.255	.418	.593		4,420	20°	7,400	560	.04
KR6-CE	.3750	.9060	.813	.345	.512	.781	.020 / .030	7,550	22°	13,200	1,380	.06
KR8-CE	.5000	1.1250	.937	.396	.730	1.000		10,700	20°	21,800	2,200	.16
KR10-CE	.6250	1.3750	1.200	.567	.856	1.250		20,100	20°	39,200	7,600	.25
KR12-CE	.7500	1.5625	1.280	.620	.970	1.375	.030 / .040	22,800	20°	47,000	10,400	.45
KR16-CE	1.0000	2.1250	1.875	.835	1.278	1.875		37,100	22°	86,200	14,000	.80

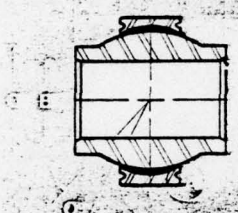
LINER MEETS PERFORMANCE REQUIREMENTS OF MIL-B-8972

BEARING MATERIALS		
	MATERIAL	HARDNESS (MIN.)
OUTER RING	AMS5643 (17-4PH)	28 Rc
BALL	AMS5630 (440C)	55 Rc
LINER	KARON	N/A

BEARING SIZE	NO LOAD BREAKAWAY TORQUE (IN LBS.)
3 & 4	0 – 5
5 thru 12	0 – 15
14 thru 16	0 – 24

KARON SPHERICAL BEARINGS with EXTENDED INNER RACE

KR-CEG Self-Aligning Rod End



SIZES	P +.000 −.015	R +.000 −.010	S +.000 −.010	X +.000 −.010	Y°
3 thru 8	.030	.015	.010	.045	20°
10 thru 12	.040	.020	.020	.055	30°
14 thru 16	.060	.020	.020	.080	30°

Detail A



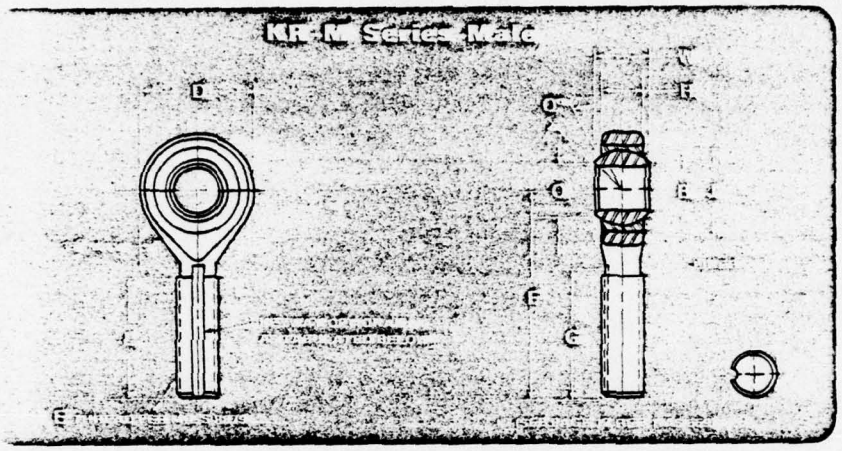
BEARING NUMBERS	B BORE DIA +.0000 −.0005	D OUTSIDE DIA +.0000 −.0005	W BALL WIDTH +.000 −.002	H RACE WIDTH +.005 −.005	O SHOULDER DIA MIN	BALL DIA REF	RADIAL DYNAMIC LOAD RATINGS (LBS.)	Q° APPROX. MISALIGN-MENT	STATIC LIMIT LOAD RADIAL (LBS.)	STATIC LIMIT LOAD AXIAL (LBS.)	APPROX. WEIGHT (LBS.)
KR3-CEG	.1900	.5625	.500	.205	.319	.437	2,720	15°	3,740	380	.03
KR4-CEG	.2500	.7400	.593	.255	.390	.593	4,420	25°	7,400	560	.04
KR5-CEG	.3125	.6875	.625	.255	.418	.593	4,420	20°	7,400	560	.04
KR6-CEG	.3750	.9060	.813	.345	.512	.781	7,550	22°	13,200	1,380	.06
KR8-CEG	.5000	1.1250	.937	.396	.730	1.000	10,700	20°	21,800	2,200	.16
KR10-CEG	.6250	1.3750	1.200	.567	.856	1.250	20,100	20°	39,200	7,600	.25
KR12-CEG	.7500	1.5625	1.280	.620	.970	1.375	22,800	20°	47,000	10,400	.45
KR16-CEG	1.0000	2.1250	1.875	.835	1.278	1.875	37,100	22°	86,200	14,000	.80

LINER MEETS PERFORMANCE REQUIREMENTS OF MIL-B-81820

BEARING MATERIALS	MATERIAL	HARDNESS (MIN.)
OUTER RING	AMS5643 (17-4PH)	28 Rc
BALL	AMS5630 (440C)	55 Rc
LINER	KARON	N/A

BEARING SIZE	NO LOAD BREAKAWAY TORQUE (IN LBS.)
3 & 4	0 – 5
5 thru 12	0 – 15
14 thru 16	0 – 24

KARON MALE ROD END BEARINGS

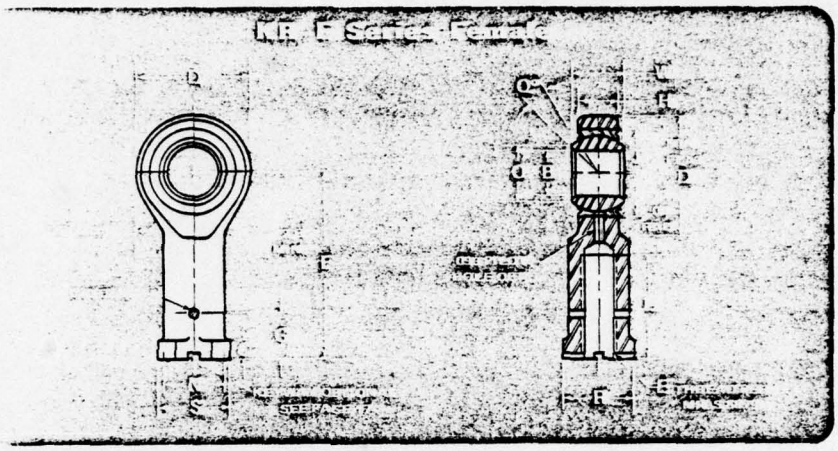


BASIC PART NUMBER	B BORE DIA +.0000 −.0005	D OUTSIDE DIA +.010 −.010	L THREAD LENGTH +.031 −.031	E THREAD SIZE UNJF-3A	F +.010 −.010	W BALL WIDTH +.000 −.002	H BODY WIDTH +.000 −.005	Q MIN	WEIGHT MAX LBS	G KEYWAY FLAT +.000 −.020	Q° MIN	J MAX HOUSING ID	LOAD RATINGS (LBS) ULT. STATIC	FATIQUE	AXIAL PROOF	NO LOAD ROTATIONAL BREAKAWAY TORQUE (IN/LBS)
KR3-M	.1900	.806	.968	5/16-24	1.562	.437	.337	.30	.072	.980	15°	.6250	2,360	1,470	1,000	0-6
KR4-M	.2500	.806	.968	5/16-24	1.562	.437	.337	.30	.072	.980	15°	.6250	4,860	2,380	1,000	0-6
KR5-M	.3125	.900	1.187	5/16-24	1.875	.437	.327	.38	.087	1.270	14°	.6875	7,180	2,770	1,100	0-6
KR6-M	.3750	1.025	1.187	3/8 -24	1.938	.500	.416	.47	.136	1.235	8°	.8125	8,550	3,570	1,660	0-15
KR7-M	.4375	1.150	1.281	7/16-20	2.125	.562	.452	.54	.183	1.402	10°	.9062	12,000	4,800	1,850	0-15
KR8-M	.5000	1.337	1.468	1/2 -20	2.438	.625	.515	.61	.278	1.589	9°	1.0000	19,500	7,680	2,040	0-15
KR10-M	.6250	1.525	1.562	5/8 -18	2.625	.750	.577	.75	.424	1.683	12°	1.1875	21,900	9,180	2,430	0-15
KR12-M	.7500	1.775	1.687	3/4 -16	2.875	.875	.640	.85	.639	1.808	13°	1.3750	29,300	11,600	2,810	0-15
KR14-M	.8750	2.025	2.000	7/8 -14	3.375	.875	.765	1.00	.963	2.121	6°	1.6250	34,500	13,100	3,320	0-24
KR16-M	1.0000	2.775	2.343	1¼ -12	4.125	1.375	1.015	1.27	2.546	2.464	12°	2.1250	80,300	30,400	4,340	0-24

ADD "K" FOR KEYWAY

COMPONENT	BALL	RACE	LINER	BODY	DESIGNATION
Material	AMS5630 440C	AMS5643 17-4PH	KARON Polymer Composite	AMS5643 17-4PH	Add Suffix S to Part Number
Hardness	55-Min Rc	28-Min Rc		39-Min Rc Passivated	
Material	AMS5630 440C	AMS5643 17-4PH	KARON Polymer Composite	4340 or 4130 Alloy Steel	Add Suffix A to Part Number
Hardness	55-Min Rc	28-Min Rc		39-Min Rc Cad. Plate	

KARON FEMALE ROD END BEARINGS

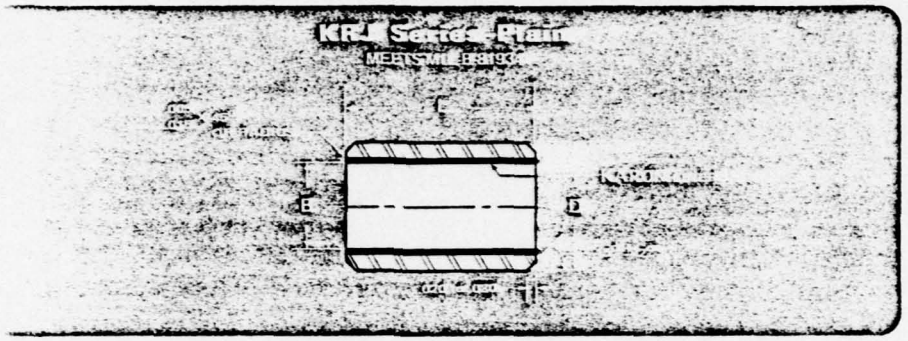


BASIC PART NUMBER	B BORE DIA +.0000 −.0005	D OUTSIDE DIA +.010 −.010	L THREAD LENGTH COMPL. MIN	E THREAD SIZE UNJF-3A	F +.010 −.010	N SHANK DIA +.010 −.010	W BALL WIDTH +.000 −.002	H BODY WIDTH +.005 −.005	O MIN	WEIGHT MAX LB.	G +.010 −.010	C +.010 −.002	R +.002 −.010	α° MIN	S REF DIA OR ACROSS CORNERS	J MAX HOUSING ID	LOAD RATINGS (LBS) ULT. STATIC	FATIGUE	AXIAL PROOF	NO LOAD ROTATIONAL BREAKAWAY TORQUE (IN/LBS)
KR3-F	.1900	.806	.750	5/16-24	1.375	.422	.437	.337	.30	.080	.375	.188	.437	15°	.500	.6250	2,360	1,470	1,000	0-6
KR4-F	.2500	.806	.750	5/16-24	1.469	.422	.437	.337	.30	.084	.375	.188	.437	15°	.500	.6250	4,860	2,380	1,000	0-6
KR5-F	.3125	.900	.875	3/8 -24	1.625	.485	.437	.327	.36	.102	.437	.250	.500	14°	.580	.6875	7,180	3,020	1,100	0-15
KR6-F	.3750	1.025	1.000	3/8 -24	1.812	.547	.500	.416	.47	.161	.437	.250	.562	8°	.660	.8125	8,550	3,570	1,660	0-15
KR7-F	.4375	1.150	1.125	7/16-20	2.000	.610	.562	.452	.54	.212	.500	.250	.625	10°	.720	.9062	12,000	4,800	1,850	0-15
KR8-F	.5000	1.337	1.250	1/2 -20	2.250	.735	.625	.515	.61	.325	.562	.250	.750	9°	.890	1.0000	19,500	8,260	2,040	0-15
KR10-F	.6250	1.525	1.375	5/8 -18	2.500	.860	.750	.577	.75	.481	.587	.375	.875	12°	1.020	1.1875	21,900	9,180	2,430	0-15
KR12-F	.7500	1.775	1.625	3/4 -16	2.875	.985	.875	.640	.85	.673	.812	.375	1.000	13°	1.160	1.3750	29,300	11,600	2,810	0-15
KR14-F	.8750	2.025	1.875	7/8 -14	3.375	1.110	.875	.765	1.00	.959	.937	.500	1.125	6°	1.300	1.6250	34,500	13,100	3,320	0-24
KR16-F	1.0000	2.775	2.125	1¼ -12	4.125	1.688	1.375	1.015	1.27	2.717	1.312	.563	1.750	12°	2.020	2.1250	80,300	30,400	4,340	0-24

ADD "K" FOR INCH/MM

COMPONENT	BALL	RACE	LINER	BODY	DESIGNATION
Material Hardness	AMS5630 440C 55-Min Rc	AMS5643 17-4PH 28-Min Rc	KARON Polymer Composite	AMS5643 17-4PH 39-Min Rc Passivated	Add Suffix S to Part Number
Material Hardness	AMS5630 440C 55-Min Rc	AMS5643 17-4PH 28-Min Rc	KARON Polymer Composite	4340 or 4130 Alloy Steel 39-Min Rc Cad. Plate	Add Suffix A to Part Number

KARON JOURNAL BEARINGS



BEARING NUMBER	NOM BORE SIZE	B BORE +.0000 −.0010	D OUTSIDE DIA See Table (a)	L MIL LENGTH LIMITS(1/32") MIN	L MIL LENGTH LIMITS(1/32") MAX	WEIGHT LBS/IN. (REF)* AL	WEIGHT LBS/IN. (REF)* CRES
KRJ4	1/4	.2515	.3760	008	014	.006	.017
KRJ5	5/16	.3140	.4386	008	018	.008	.022
KRJ6	3/8	.3765	.5012	008	022	.009	.025
KRJ7	7/16	.4390	.5638	008	028	.010	.028
KRJ8	1/2	.5015	.6265	008	028	.011	.031
KRJ9	9/16	.5640	.6892	008	036	.013	.036
KRJ10	5/8	.6265	.8142	008	044	.022	.061
KRJ11	11/16	.6890	.8767	008	052	.023	.064
KRJ12	3/4	.7515	.9393	008	052	.025	.070
KRJ14	7/8	.8765	1.0645	008	052	.029	.080
KRJ16	1	1.0015	1.1898	008	060	.033	.091
KRJ18	1 1/8	1.1265	1.3148	010	060	.037	.101
KRJ20	1 1/4	1.2515	1.4398	012	068	.040	.111
KRJ22	1 3/8	1.3765	1.5648	012	068	.044	.122
KRJ24	1 1/2	1.5015	1.7523	012	088	.065	.179
KRJ26	1 5/8	1.6265	1.8773	016	096	.070	.193
KRJ28	1 3/4	1.7515	2.0023	016	096	.075	.207
KRJ32	2	2.0015	2.2523	016	096	.085	.234

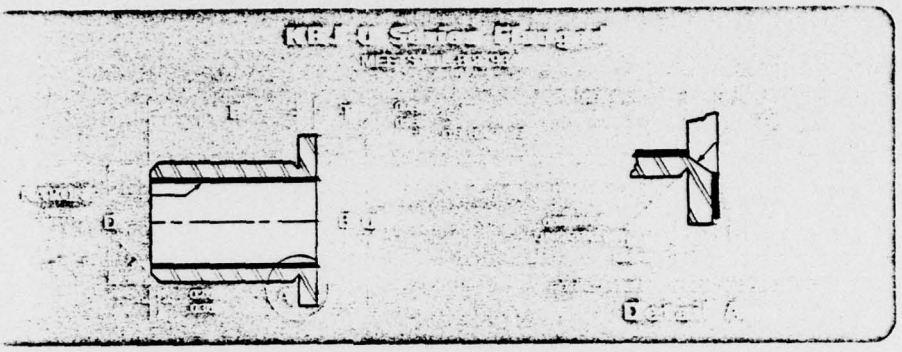
ADD SUFFIX FOR DESIRED LENGTH			
CODE	LENGTH +.000 −.010	CODE	LENGTH +.000 −.010
-008	.250	-048	1.500
-009	.281	-050	1.562
-010	.312	-052	1.625
-011	.344	-054	1.687
-012	.375	-056	1.750
-014	.437	-058	1.812
-016	.500	-060	1.875
-018	.562	-062	1.937
-020	.625	-064	2.000
-022	.687	-066	2.062
-024	.750	-068	2.125
-026	.812	-070	2.187
-028	.875	-072	2.250
-030	.937	-074	2.312
-032	1.000	-076	2.375
-034	1.062	-078	2.437
-036	1.125	-080	2.500
-038	1.187	-082	2.562
-040	1.250	-084	2.625
-042	1.312	-086	2.687
-044	1.375	-088	2.750
.046	1.437	-096	3.000

BEARING MATERIALS			
	MATERIAL	CONDITION	SYMBOL
OUTER JOURNAL	17-4PH	27 Rc Min	S
	2024 AL	T851/T8511	Y
LINER	KARON	N/A	B, V or H

(a) TOLERANCE OF D
AL – ±.0005
CRES + .0000, - .0005

Roller - Assy

KARON JOURNAL BEARINGS



FLANGED BEARING NUMBER	B NOM BORE SIZE	B BORE + .0000 - .0010	D OUTSIDE DIA See Table (a)	U FLANGE DIA + .000 - .020	L MIL LENGTH LIMITS (1/32") MIN	L MIL LENGTH LIMITS (1/32") MAX	FLANGE WEIGHT (REF)* AL	FLANGE WEIGHT (REF)* CRES	T FLANGE WIDTH
KRJ4-U	1/4	.2515	.3760	.750	008	014	.003	.007	.0625
KRJ5-U	5/16	.3140	.4386	.812	008	018	.003	.007	
KRJ6-U	3/8	.3765	.5012	.875	008	022	.003	.007	
KRJ7-U	7/16	.4390	.5638	.937	008	028	.003	.008	
KRJ8-U	1/2	.5015	.6265	1.000	008	028	.004	.010	
KRJ9-U	9/16	.5640	.6892	1.125	008	036	.004	.011	
KRJ10-U	5/8	.6265	.8142	1.250	008	044	.005	.014	
KRJ11-U	11/16	.6890	.8767	1.375	008	052	.007	.020	
KRJ12-U	3/4	.7515	.9393	1.500	008	052	.009	.023	
KRJ14-U	7/8	.8765	1.0645	1.625	008	052	.009	.025	
KRJ16-U	1	1.0015	1.1898	1.750	008	060	.010	.027	
KRJ18-U	1 1/8	1.1265	1.3148	1.875	010	060	.014	.041	.0937
KRJ20-U	1 1/4	1.2515	1.4398	2.000	012	068	.018	.050	
KRJ22-U	1 3/8	1.3765	1.5648	2.125	012	068	.019	.053	
KRJ24-U	1 1/2	1.5015	1.7523	2.250	012	088	.019	.054	
KRJ26-U	1 5/8	1.6265	1.8773	2.375	016	096	.020	.056	
KRJ28-U	1 3/4	1.7515	2.0023	2.500	016	096	.023	.064	
KRJ32-U	2	2.0015	2.2523	2.750	016	096	.026	.072	

* ADD THIS WEIGHT TO JOURNAL WEIGHT ON PAGE 12

ADD SUFFIX FOR DESIRED LENGTH			
CODE	LENGTH +.000 -.010	CODE	LENGTH +.000 -.010
-008	.250	-048	1.500
-009	.281	-050	1.562
-010	.312	-052	1.625
-011	.344	-054	1.687
-012	.375	-056	1.750
-014	.437	-058	1.812
-016	.500	-060	1.875
-018	.562	-062	1.937
-020	.625	-064	2.000
-022	.687	-066	2.062
-024	.750	-068	2.125
-026	.812	-070	2.187
-028	.875	-072	2.250
-030	.937	-074	2.312
-032	1.000	-076	2.375
-034	1.062	-078	2.437
-036	1.125	-080	2.500
-038	1.187	-082	2.562
-040	1.250	-084	2.625
-042	1.312	-086	2.687
-044	1.375	-088	2.750
-046	1.437	-096	3.000

BEARING MATERIALS			
	MATERIAL	CONDITION	SYMBOL
OUTER JOURNAL	17-4PH	27 Rc Min	S
	2024 AL	T851/T8511	Y
LINER	KARON	N/A	B, V or H

(a) TOLERANCE OF D
AL – ±.0005
CRES + .0000, - .0005

PARAMETER DEFINITIONS

RADIAL DYNAMIC LOAD

The radial dynamic load capacities noted in this catalog are based on the specification of MIL-B-81820. These requirements are configured for .0045 inches of maximum wear after 25,000 cycles for the inner ring oscillating at plus and minus 25° (50° total) and 10 cpm. The maximum wear is measured under the operating load.

RADIAL LIMIT LOAD

The radial limit load is the maximum radial load which will result in a permanent set in the bearing no greater than .003 inch after the load is applied for three minutes.

AXIAL LIMIT LOAD

The axial limit load is the maximum axial thrust which will result in a permanent set in the bearing no greater than .005 inch after three minutes of application of the thrust load.

ULTIMATE RADIAL AND AXIAL LOADS

The ultimate radial and axial loads is 1.5 times the radial limit and axial limit loads. At loads equal to this magnitude, no race or ball fracture will occur, nor will the ball be disengaged.

FATIGUE LOAD

The fatigue load capacities noted in this catalog are based on the specification of MIL-B-81935. These load capacities are proposed for the successful accumulation of a minimum of 50,000 vibrating cycles.

CALCULATIONS

(1) PV RATINGS = Pressure X Velocity: lbs/sq.in. X ft/min.

PRESSURE

The bearing pressure (lbs/sq.in.) is calculated by dividing the bearing load (C) by the projected bearing area. The projected bearing area is determined by multiplying the ball diameter (d) by the width of the outer race (H) for sphericals; or the inner diameter (B) multiplied by the length (L) for journals.

Spherical

$$P_{psi} = \frac{C}{d \times H}$$

Journal

$$P_{psi} = \frac{C}{B \times L}$$

VELOCITY

The surface speed for a spherical inner race can be calculated according to the following formula:

$$V \text{ feet per minute (Oscillation)} = \frac{(\text{Number of degrees per cycle}) \times (\text{Cycles per min.}) \times (\text{Ball diameter in inches}) \times \pi}{360 \qquad 12}$$

$$V \text{ feet per minute (Rotation)} = \frac{(\text{Ball diameter in inches}) \times \pi \times \text{RPM}}{12}$$

(2) COEFFICIENT OF FRICTION

Spherical

$$\mu = \frac{\text{Operating Torque}}{\text{Ball Radius}} \div \text{Bearing Load}$$

Journal

$$\mu = \frac{\text{Operating Torque}}{\text{Shaft Radius}} \div \text{Bearing Load}$$

MATERIALS

KARON Liner – For applications (MIL-B-81820) requiring high unit loading and low velocities signify Type "B". Example – Spherical KR8-CWGB; Rod End KR8-MB or Journal KRJ5-UB-08.

For applications requiring low to medium unit loading and medium to high velocities signify Type "H". Example – Spherical KR8-CWGH; Rod End KR8-MH or Flanged Journal KRJ5-UDH-08.

For marine environments signify Type "V". Example – Spherical KR8-CWGV; Rod End KR8-MV or Journal KRJ5-UV-08. Additional liner types are available upon request for specific requirements such as electrical conductivity, abnormality low friction and nuclear radiation.

Metal Components – Generally these are constructed from standard materials; namely 440C stainless steel for the inner race and 17-4PH stainless steel for the outer housing. The utilization of these stainless steels insures high corrosion resistance and mechanical strength.

Other choices of materials may be used in lieu of stainless steel, such as aluminum and ceramic coated titanium, predicated on the performance characteristics required.

INSTALLATION

The KARON bearing, through its unique design, offers the user consistantly low breakaway torque, while displaying no radial play (zero backlash). To maintain this low breakaway torque in use, the interference fits between 1) the housing bore and the O.D. of the bearing and 2) the inner ring bore of the bearing and the shaft shall be no greater than line to line. If the application requires interference fits greater than line to line, contact your Kamatics Sales Engineer for his recommendation.

Good bearing practice dictates that:

Housing Installation – Bearings should be installed in the housing by applying axial pressure to the outer ring of the bearing. The housing bore into which the bearing is to be inserted should have a slight chamfer or radius to ensure the proper installation of the bearing.

Shaft Installation – Bearings should be installed on the shaft by applying axial pressure to the inner race of the bearing.

FLUID COMPATIBILITY

The compatibility of KARON liner material with fluids of various types has been established by long time exposure at ambient temperatures and elevated temperatures and endurance testing after exposure. Some of the fluids which have been evaluated for compatibility are:

- Skydrol 500A – Hydraulic Fluid
- TT-S-735 Type VII – Standard Test Fluid
- MIL-L-7808 – Lubricating Oil
- MIL-H-5606 – Hydraulic
- MIL-A-8243 – Anti-Icing Fluid
- MIL-L-2104 (Grade 10) Lubricating Oil
- MIL-T-5624 – JP4 and JP5 Jet Fuels
- TT-T-548 – Toluene
- TT-B-846 – Butyl Alcohol
- O-A-548 – Ethylene Glycol
- Water (both fresh and salt)
- Mil-L-23699 – Lubricating Oil

OTHER PRODUCTS

from KAMATICS corporation

MARINE ENVIRONMENTS

By combining our KARON liner with a KARAMITE® coated ball, a bearing system is available offering excellent resistance to corrosion and wear. Tests run by a leading manufacturer of hydrofoils proved the life of this bearing system is 14 times greater than its nearest competitor (4400 hours vs. 296 hours), in a saltwater environment. This bearing system is offered in most standard sizes.

COLD TEMPERATURE ENVIRONMENTS

The KARON liner has proven to be superior to standard fabric liners when required to operate in cold environments (–100° F). Many times during normal high altitude flying, bearings are subject to these temperatures which result in accelerated liner wear. This liner wear greatly reduces the life of the bearing. KARON's ability to resist wear at cold temperatures offers the user a product that reduces maintenance costs and keeps aircraft flying.

SPECIAL APPLICATIONS

KARON can be applied to most metals, thereby offering an excellent bearing surface in almost any configuration due to its ability to be molded. It also resists corrosion and therefore can protect the base metal, offering the user a secondary benefit.

KACARB® PRODUCTS

In order to overcome the temperature barrier, a carbon/ceramic bearing was developed in 1966, designated KACARB. This proven bearing system can deliver long life in environments exceeding 1200° F. KACARB bearings are presently operating in applications ranging in diversity from the steel industry to jet engines.

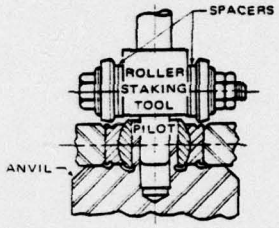
Contact your Kamatics Sales Engineer for any additional information you may require.

TYPICAL BEARING INSTALLATION PROCEDURES

ROLLER STAKING PROCEDURE

1 Press bearing into housing and locate on center.

2 While supporting bearing on anvil, use roller staking tool to stake outer race over housing. Repeat on opposite side.

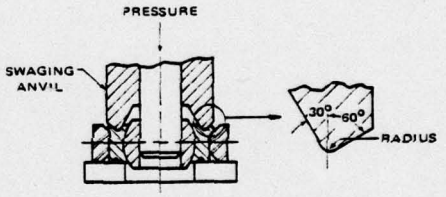


SWAGING PROCEDURE

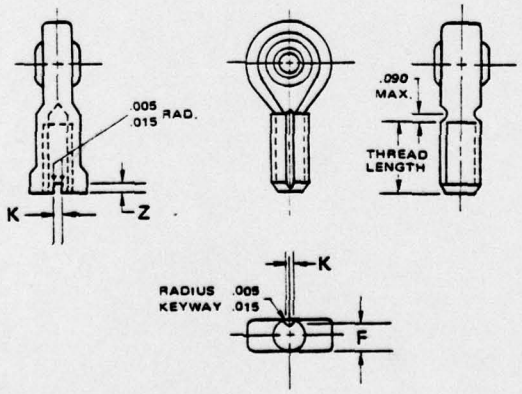
1 Apply swaging anvil pressure.

2 Rotate anvil 90° and apply pressure.

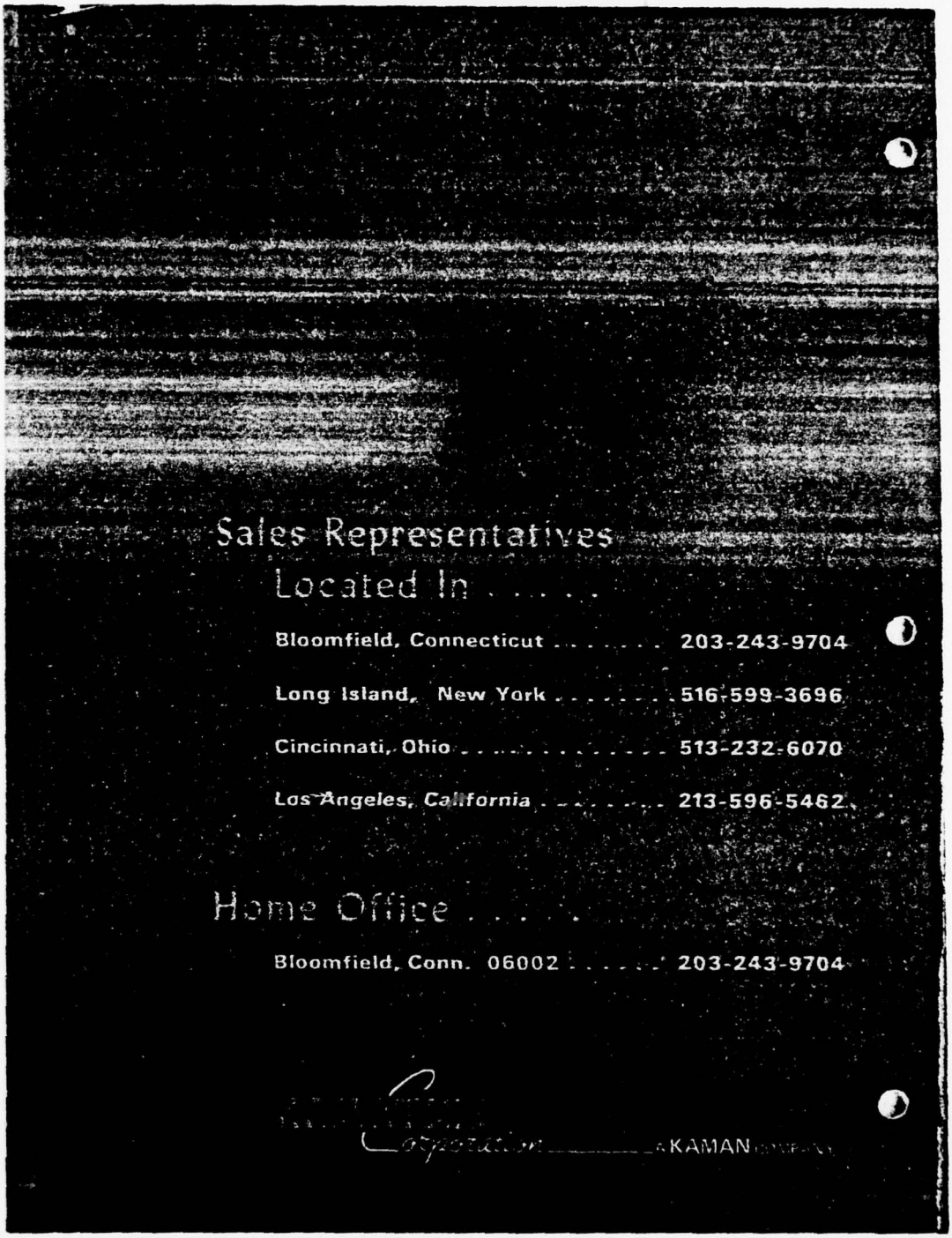
3 Repeat items 1 and 2 three times.



STANDARD ROD END KEYWAY (REF. NAS 559)



THREAD SIZE	Z +.005 −.000	K +.005 −.000	F +.000 −.005
.250	.056	.062	.201
.312	.056	.062	.260
.375	.056	.093	.311
.437	.069	.093	.370
.500	.069	.093	.436
.562	.077	.125	.478
.625	.077	.125	.541
.750	.077	.125	.663
.875	.086	.156	.777
1.000	.094	.156	.900
1.125	.094	.187	1.010
1.250	.116	.187	1.136
1.375	.116	.250	1.236
1.500	.116	.250	1.361
1.625	.129	.250	1.477
1.750	.129	.312	1.589
1.875	.129	.312	1.714
2.000	.129	.312	1.839
2.125	.129	.312	1.955
2.250	.129	.312	2.030


Sales Representatives
Located In . . . . .
Bloomfield, Connecticut 203-243-9704
Long Island, New York 516-599-3696
Cincinnati, Ohio 513-232-6070
Los Angeles, California 213-596-5462
Home Office . . . . .
Bloomfield, Conn. 06002 203-243-9704
KAMAN

APPENDIX U

APPENDIX U

DRSS DATA BANK

APPENDIX U

DRSS DATA BANK

(1) Handbook for Submarine Improvement
NUSC#551C, 1 Dec 72, W/CH-5 24 Mar 76

(2) Material Ident. & Control (MIC) for Piping Systems Vol. I, Nov. 76
NAVSEA 0948-LP-045-7010

(3) I, O & M for AN/BRA-24C(U) Antenna Transfer Assy, Nov. 76
NAVSEA 0967-LP-608-5010

(4) T.M. for AN/BRA-24A(U), Aug. 69
NAVSEA 0967-LP-301-2010, 11

(5) T.M. for AN/BRA-18C, June 68
NAVSHIPS 0967-325-8010, Vol. I

(6) NUSC D02387, Adapter, RF Cable Conn. Interface & Comp.
Arrgt., MX- /BRR

(7) NUSC D02378, RF Cable Assys, Type I,
CG- /B; ND Type II CG- /B

(8) NUSC D02286, Amplifier, RF Conn. Interface & Chassis Arrgt.
AM- /BRR

(9) SPEC: NUSC-C-342/4141-279 dated 20 July 1977
Cable, RF, Buoyant, General Spec. for

(10) MIL-C-28751(EC) Cable, RF RG-373/U dated 27 July 70

(11) MIL-C-28726(EC) Cable, Special Purpose, RF, Buoyant,
Co-axial Type RG-384/U dated 9 Jan 70

(12) 02-702-001 Std. Buoyant Cable Baseline C/.A Installation

(13) 02-702-02 Prg. Desc. Overview

(14) N0039-79-R-0131(S) Solicitation dated Feb. 79

(15) DRSS Proposal, dated Mar. 79

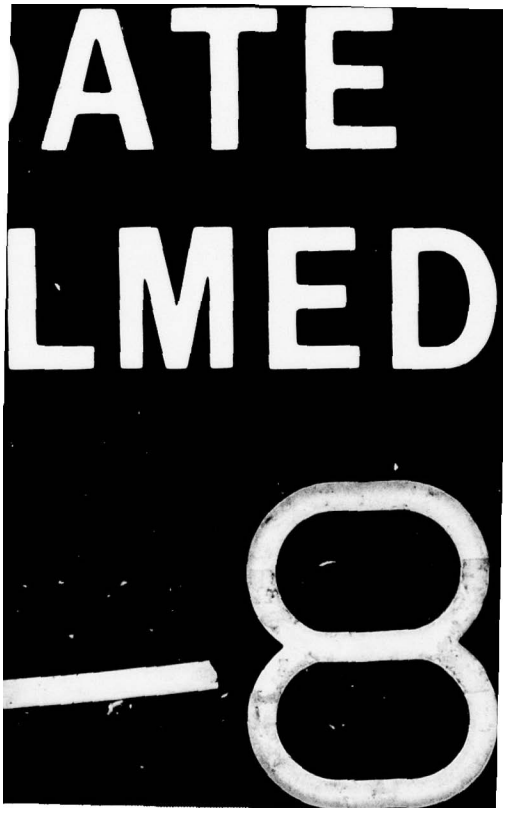
(16) Minutes:
3/8/79 @ NUSC re DRSS
6/6/79 @ CID re "Kickoff"
8/8/79 @ Crystal City re Month 2 Review
9/12/79 @ Crystal City re Month 3 Review
10/18/79 @ CID re Month 4 Review
12/5/79 @ CID re Month 6 Review

(17) Presentations:
7/2/79 DRSS Month 1 Prog. Review by B.S.
8/8/79 DRSS Month 2 Prog. Review by W.R.
9/12/79 DRSS Month 3 Prog. Review by W.R.
10/11/79 DRSS Month 4 (IDR) Review by W.R.
11/28/79 DRSS Month 6 Prog. Review by W.R.

(18) NAVSEA Instruction 5511.46

(19) Sys. Des. Trade Study, Reports USAF DI-S-3606/S-128-1, INo

(20) Memos:
3/7/79 Subsafe-DRSS
3/12/79 Trip Report to Bowen Tools Inc
4/18/79 Non-Nuclear Discrepant Mat'ls - DRSS


ATE
LMED
8